MANAGEMENT EDITION

THE Petroleum Engineer

Exploration
Drilling
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Petrochemical
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Oil . . Gas
Products
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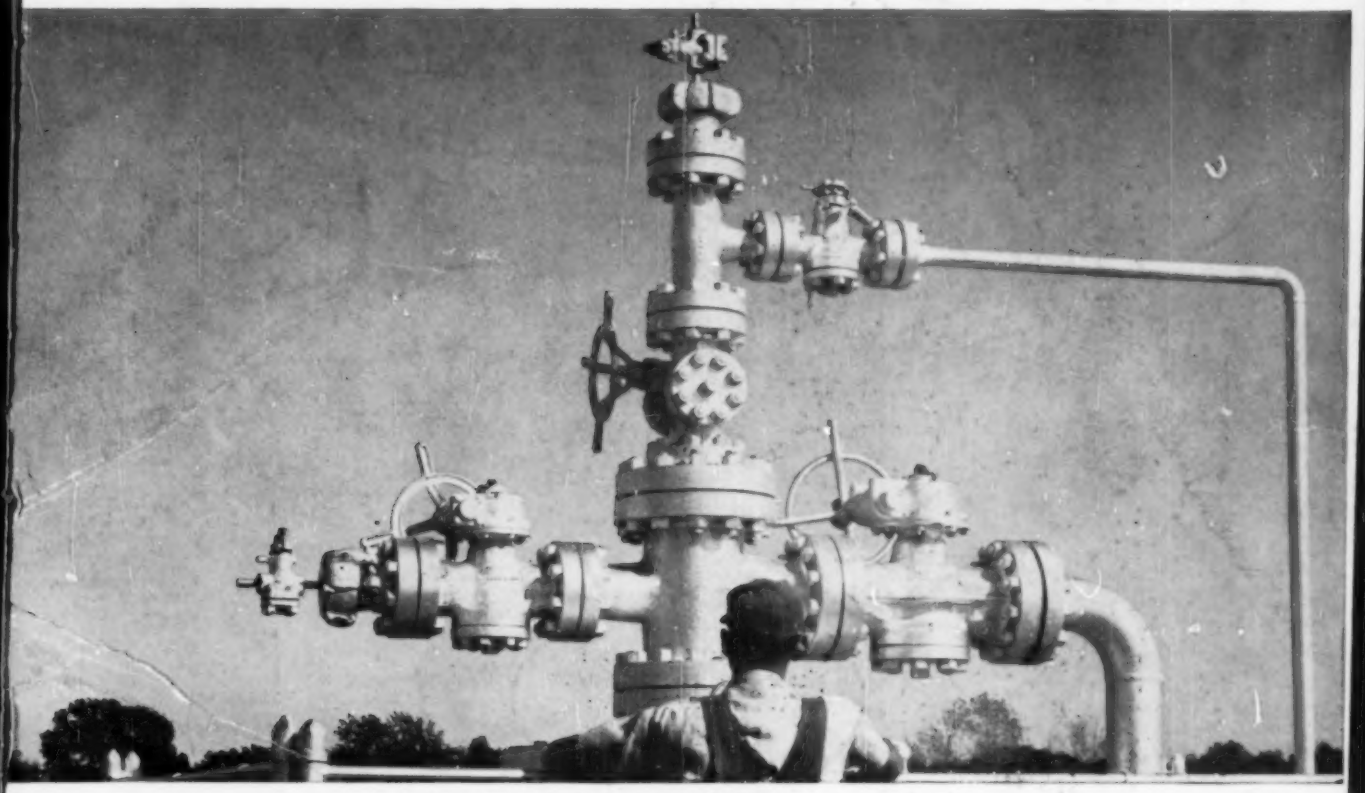
This Year of Prosperity — 1956
Don't Overpay Your Taxes
Modern Genii of the American Motorist — Additives
Better Communications



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JANUARY 1956

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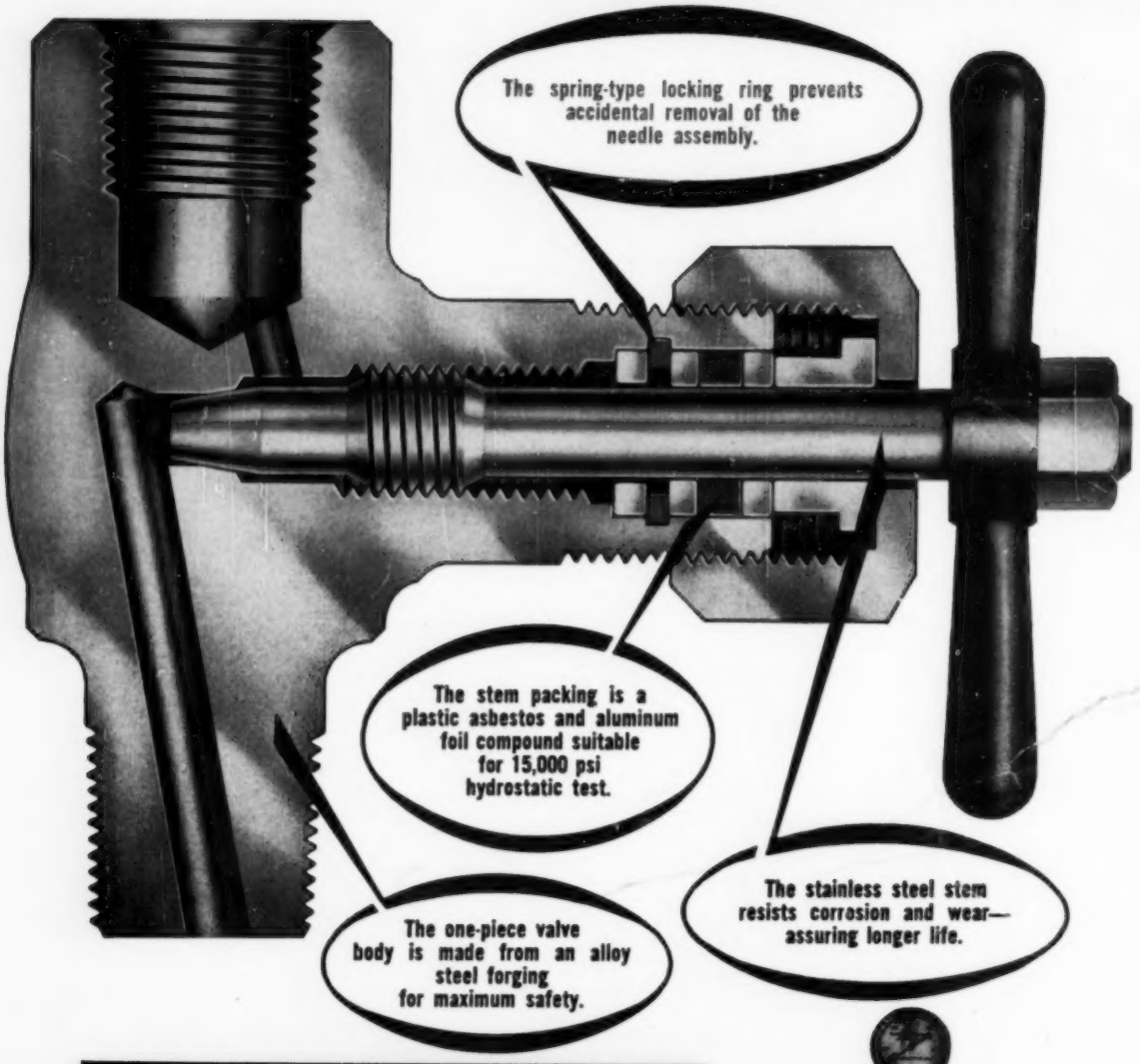
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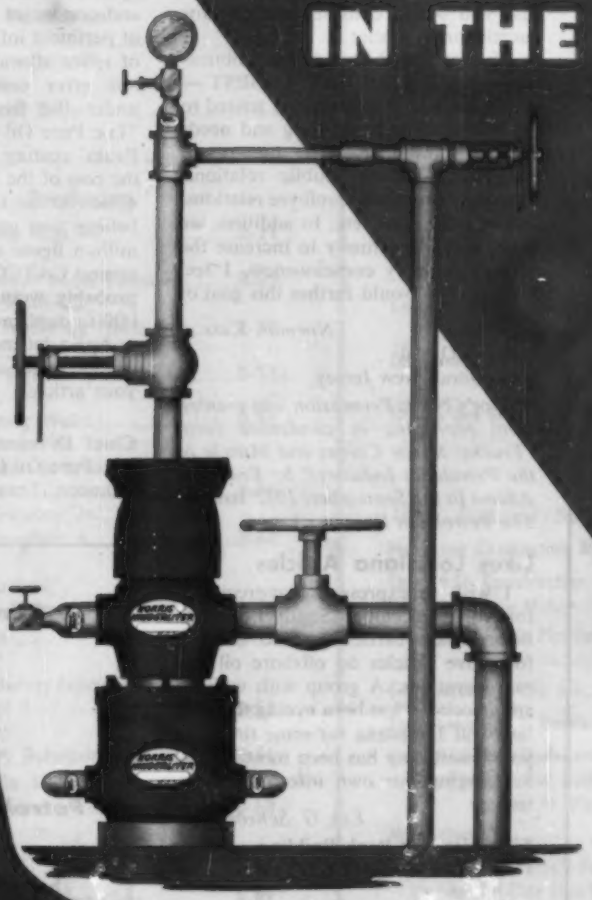

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LETTERS

Trucks on the Move

The October issue of EMPIRE, a publication of Cities Service Oil Company, carried a reference to a 12-page pictorial feature by you on the growth of the trucking industry. Checking with PE's New York office, we learned that you would consider requests for permission to reprint it.

I feel it would fit into our publication — THE DRIVERS' DIGEST — which is a monthly magazine geared to the interests, understanding and needs of professional drivers. It attempts to emphasize safety, public relations, economy, employer-employee relations, selling techniques, etc. In addition, we take every opportunity to increase the driver's industry consciousness. I feel your feature would further this goal of ours.

Norman Karr

Driver's Digest
Englewood, New Jersey

(Editor's Note: *Permission was granted from reprinting in condensed form "Trucks: Magic Carpet and Muscle of the Petroleum Industry," by Ernestine Adams in the September, 1955 issue of The Petroleum Engineer.)*

Likes Louisiana Articles

I wish to express my appreciation for your December South Louisiana Issue which carries graphic and informative articles on offshore oil and gas operations. A group with which I am associated has been eyeing the tidelands off Louisiana for some time and your insert map has been most helpful in bringing our own information up-to-date.

Eric G. Schroeder

First National Bank Building
Dallas, Texas

Alberta Picture Desired

In the April, 1955, issue of The Petroleum Engineer (page B-3), there was a picture of the first oil well drilled in Alberta. I was raised in the shadow of this rig.

Would it be possible to obtain a copy of this picture, suitable for framing?

John B. Maughan

Stanolind Oil & Gas Company
Calgary, Canada.

Editor's note: *The original of this picture is on the wall of N. E. Tanner, president of Trans-Canada Pipe Lines, Ltd. We are sorry that we are unable to provide you a print, however, we feel sure that if you contact Mr. Tanner, he would be agreeable to your making a copy print.*

Louisiana Maps

I can frankly state that you have done the best job I have seen yet in the way of maps. I would say you are to be congratulated.

Your article, "Louisiana Offshore Picture," I feel, is very comprehensive and condenses a considerable amount of pertinent information in the amount of space allocated. There is, however, one error contained in the caption under the first photograph, stating, "The Pure Oil Company's 'R. W. McIlvain' costing $1,500,000." Actually, the cost of the McIlvain complete with 45-ton crane is less than $500,000. I believe you got the one and one-half million figure as being the cost of the several CATCO tenders. The McIlvain probably would cost around $1,500,000 to duplicate.

Again let me thank you for the excellent maps and compliment you on your article.

I. W. Alcorn

Chief Division Production Engineer
The Pure Oil Company
Houston, Texas

Annual Index

for

1955

The

Petroleum Engineer

The editorial index of all articles published in *The Petroleum Engineer* during 1955 is now available.

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Please state company position and don't forget to include your address.

THE *Petroleum* Engineer **Management Edition**

Exploration—Drilling—Producing • Refining—Petrochemical—Gas Processing • Oil and Gas Pipelining

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Are We Better Than We Think?

A Study in Power

The petroleum industry has blamed its neglected public relations time after time for many of its political problems and for the apparent lack of consumer understanding.

Now a political scientist claims we've been all wrong — that our public relations are eminently successful and our political needs invariably taken care of by state and national governments.

We're better than we think or the professor thinks we're better than we are. We suspect the latter.

IN facing the New Year of 1956 and thinking of the problems ahead, we were inclined to list first the need for greater public understanding. That was before we read Robert Engler's "Oil and Politics" in *The New Republic* and got our first real encouragement about the effect of the industry's public relations.

The professor of political science at Sarah Lawrence College is not *for* us but if the oil industry is as good at politics and public relations as he says, then he can't help admiring us.

In his two-year search, the Bronxville, New York, teacher "found an oil government — a private government of oil carefully interwoven with public government run by oil." He contrasts his inquiry to that of Ida Tarbell in her famous 1904 history of Standard Oil by saying that where she assumed "the badness of bigness" he has "no illusion about the little guys in oil."

The six articles in the series are plugged as "A Study in Power" or "how one of America's richest industries protects its interests and persuades public opinion and public officials that what is good for oil is good for all." In this particular viewpoint, it is considered reprehensible to seek understanding from the public or to pursue the best course for the industry in state or national or international politics. It is even worse to be as successful in public relations as the author claims we are.

North Dakota, in the opinion of Mr. Engler, has been moved from its radical agrarian tradition toward the conservative oil-industry political view through sheer weight of public relations of oil associations and companies. The effort by the industry to hold state taxes down is considered an alarming state of affairs.

Listen to Professor Engler and no oil man will ever worry about the percentage depletion allowance being rescinded. He indicates that a test for membership in the House Ways and Means Committee and the Senate Finance Committee is whether the prospect is in favor of the 27½ per cent oil and gas depletion allowance.

The OIIC is convicted by its own words of indoctrinating schools — even Cub Scouts and Boy Scouts — on the importance of oil in American life. The doings of the OIIC are reviewed with pretty dark suspicion. We are left with the idea that the organization's work is an insinuating propaganda and much more successful than the industry has realized.

The author seems a little discouraged about an oil policy being publicly determined by any investigation. "Questions about private power and public purpose seem out of order in a culture where things are always getting better," he complains.

If you are concerned about the Fulbright bill to take natural gas producers from under FPC control, are discouraged about the renewed fight against percentage depletion allowance, are finding it hard to meet taxes, you should take a look at this inflated view of your power.

It could be we are better than we ever dreamed. It could be the public is coming to a better understanding of the oil industry — its importance and its great service.

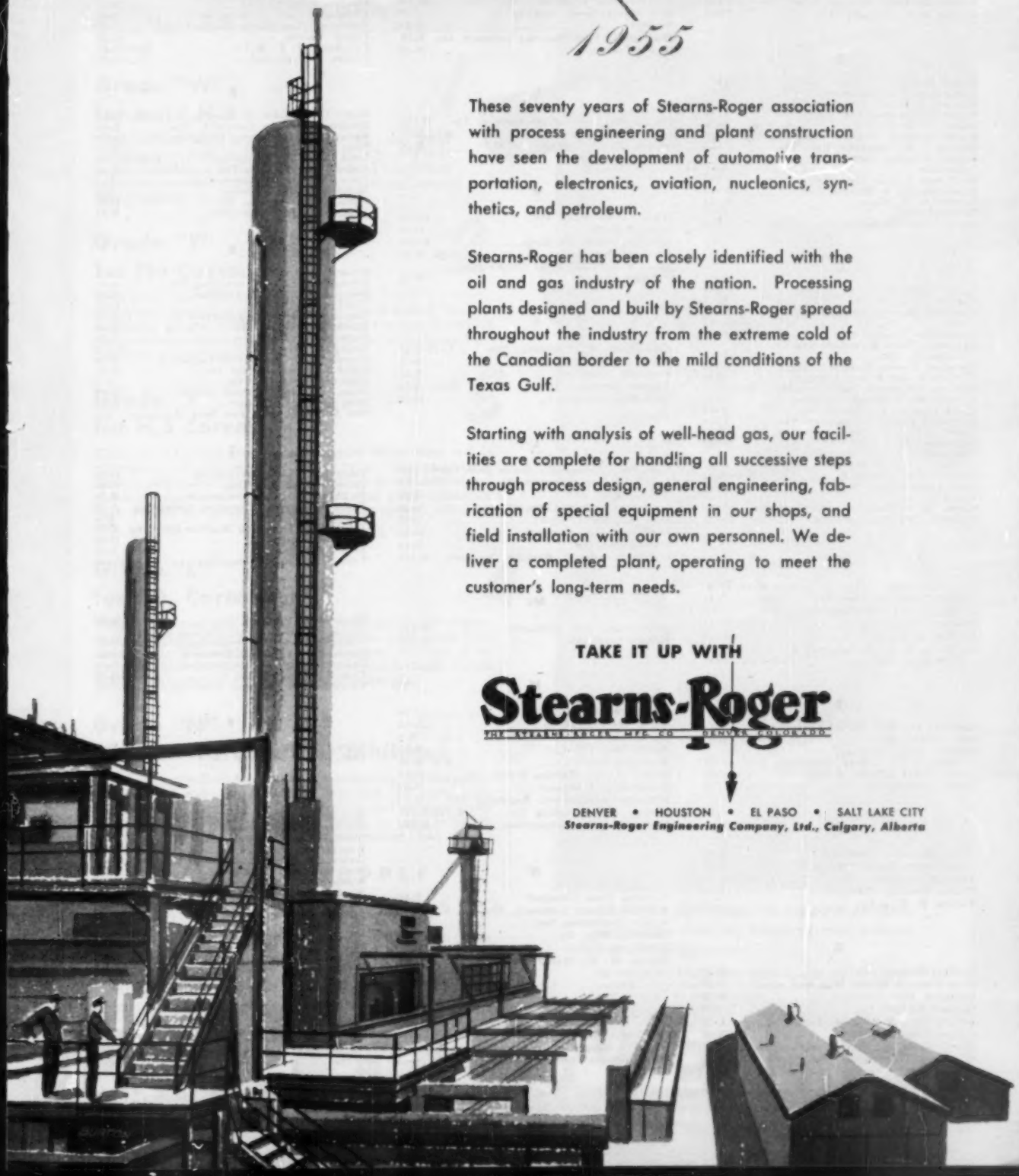
And we defy any industry to claim it has had more to do with bringing about "a culture where things are always getting better" than the petroleum industry.

Ernestine Adams

1885

70 TO GROW ON...

1955



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This A.I.S.I. 4820 nickel-molybdenum alloy steel rod acquires high strength and toughness plus corrosion resistance through complete heat treatment —liquid-quenching, tempering, stretch-straightening and proof-testing.

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This alloy steel rod, containing boron, is liquid-quenched, tempered, stretch-straightened and proof-tested. Its exceptional fatigue resistance under high loading is setting new service records at great depth; or for uses where tubing sizes are limited.

Grade "T" for H_2S Corrosion — 3

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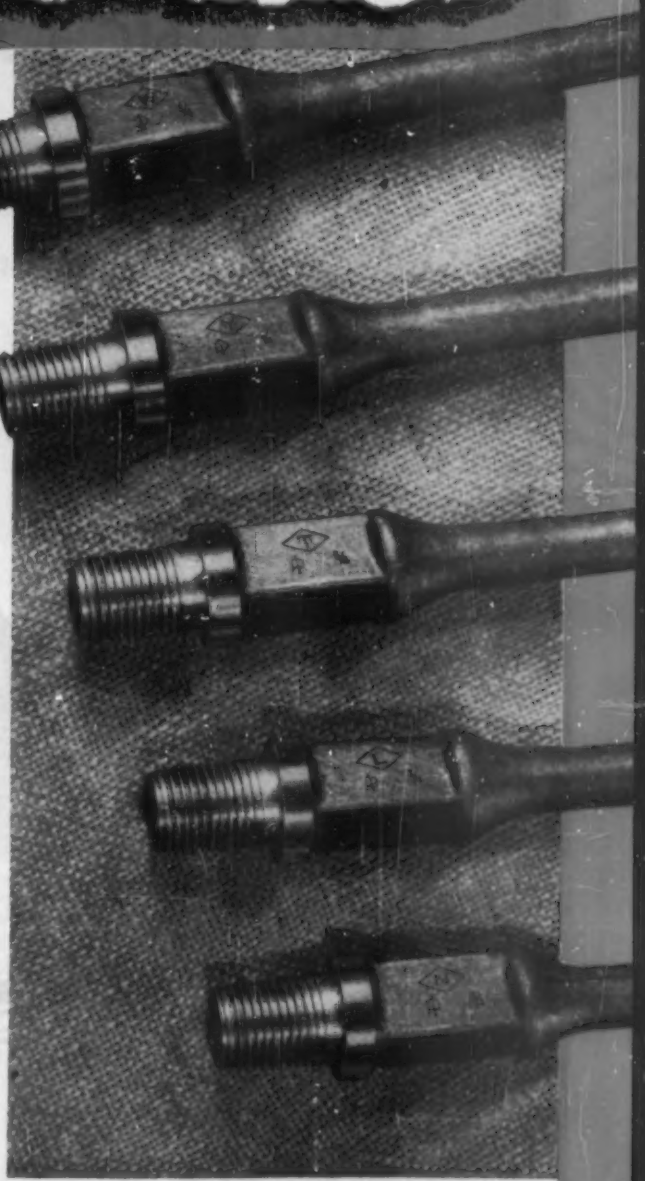
Grade "L" for CO_2 Corrosion — 4

This is a normalized, tempered and air-cooled rod of controlled, special analysis, nickel-chromium alloy steel. The rod has exceptional fatigue resistance and, because of its unique grain structure, is suitable for use in wells which contain salt-water or free carbon dioxide gas.

Grade "N" for Non-Corrosion or Inhibited — 5

This is a controlled, fine-grain, open-hearth, carbon-manganese steel rod of uniform quality that has been fully normalized after forging, to neutralize end stresses from forging. It has been proven for years, in non-corrosive operations, as the industry's most economical buy.



SELECT the right sucker rod for YOUR pumping application from the industry's most modern manufacturing plant.

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620 MILES OF ALASKAN PIPELINE —EVERY INCH A BATTLE

Temperatures of 60 below, muskeg, permafrost, snow, swamps, mountains—you get 'em all laying a pipeline from Haines to Fairbanks

UNDER THE MUSKEG, PERMAFROST. A Cleveland ditcher powered by a D8800 digs through a layer of muskeg and then through hard permafrost. A D6 is towing the ditcher while a Bucyrus-Erie backhoe, powered by a D315 Engine, backfills.

TWO LINCOLN WELDERS are mounted on a D6. In good weather the welding crews, seen here near Dot Lake, Alaska, have been averaging four miles a day.

Nature has been throwing the book at Williams Brothers Co. since December, 1953. On that date, the Tulsa pipeliners began working on the Haines to Fairbanks Pipeline, one of the most ambitious welded pipelines ever attempted.

It's been a grueling, ask-no-quarter test for crews and machines. But they're bringing the job in on schedule—these doughty pipeliners from all over the U. S. and their all-CATERPILLAR* fleet of pipelayers, 'dozers, engines and electric sets.

Clearing began in December, 1953, with snow drifted up to six feet and 15 days of temperatures ranging from 30 to 60 below. But D8s equipped with No. 8A Bulldozers cleared a mile a day, increasing to 2½ miles a day as weather improved. Covered at night with tarps and warmed by eight No. 2 kerosene lanterns, the CAT* D8 Tractors started easily each day.

In April, the first of five big yellow tractors plunged through the ice—only

IN A MUSKEG SWAMP A D6 equipped with a No. 6A Bulldozer backfills a trench. A D8 is being used as a stomper to hold down the pipe.

a few feet of its 22-foot boom showing. Recovered and flushed out, the D6 went back on the job with only a bent boom to show for its experience.

Half the Alaskan section of the line is underground. To tuck it in, Williams Brothers proved it was possible to dig permafrost with a ditcher. A D8800 powered the Cleveland ditcher and a lead Cat D6 dragged the ditcher more than 110 miles.

In the water-covered muskeg swamps there was a double problem. Under the moss-like muskeg lay permafrost. Skillful operators kept the big yellow tractors moving—although they might have been mired by the muskeg or slipped helplessly on the hard permafrost. But the Caterpillar D6 Tractors, with their oil clutches, kept production as high as 3500 feet of ditch in 24 hours. And only two clutch adjustments were required during the entire operation.

"Those oil clutches are giving awfully good service," reports E. M. Hubach, Superintendent of the Canadian section of the job. "Only one had a disc break and they've rarely been adjusted. Our Cat machines stay with us. They walk right through that muskeg."

The Canadian section of the job has a complete spread of Caterpillar-built equipment—eight pipelayers, four bulldozers, three tow tractors and two Cat powerplants on Bucyrus-Erie Shovels.

And each of the three comfortable crew camps for more than 300 men has been powered by Caterpillar D8800 Electric Sets.

The performance of all this equipment has proven once again that tough jobs are Caterpillar jobs.

CATERPILLAR TRACTOR CO., PEORIA, ILLINOIS, U. S. A.

*Both Cat and Caterpillar are registered trademarks—®

ONE OF THE FLEET OF MD6s works on a bending operation in the Yukon. Bending crew has been averaging about five miles a day.

HIGHLIGHTS

★ ★ ★

Digest of News and Comment

Merrill Petroleums, Ltd., Calgary, Canada, will increase its oil and gas reserves and daily production by some 60 per cent through the recent purchase of Cancoll Oil & Gas Company, Ltd. Sale involved $5,000,000 cash payment and $2,250,000 yearly payment from 1957 through 1960, as well as $4,000,000 out of production and overriding royalty from non-proven acreage.

★ ★ ★

Government may step in to halt cutthroat competition that has ruined New Jersey gasoline price structure, predicts Senator Humphrey of Minnesota. Many dealers claim they are being forced out of business in one of the nation's most serious gas price wars.

★ ★ ★

Oil proration in Texas for the month of January will hold its high pace set in December. A 17-day producing schedule has been set with daily average flow in the state estimated at 3,323,312 bbl. Lower crude stocks and colder winter (set at 14.2 per cent worse than last, statistics show) are given as reasons for continuation of the high allowable rate.

★ ★ ★

Motor vehicle mileage has sur-passed the half-trillion mark this year, rolled up by the 72 million drivers of cars, trucks, and buses in the U. S. Automobile Manufacturers Association, which compiled these figures, also said that one-fourth of the delivered cars consisted of taxes. Highway users paid $6.2 billion in taxes last year.

★ ★ ★

Treasury's short term borrow-ing costs advanced to a new high in December, reaching a rate of 2.591 per cent for its short term money. At the current level, due in part to yearly demand for "Christmas money," the government is paying the highest rate since "bank holiday" days of 1933.

★ ★ ★

More, not less, controls are seen for the natural gas industry, with the position of the independent producer even more precarious, according to Joseph Hedrick, president of Natural Gas Pipe Line Company of America, Chicago. The recent "field price" rate decision involving a rejection of rate increase to Panhandle Eastern Pipe Line Company, "can have little or no good for the independent producer, who gradually has been pinched more and more by the actions of the Federal Power Commission."

★ ★ ★

Higher wholesale prices for domestic heating oils, diesel fuels and kerosine have been posted in the Midwest by Standard Oil of Indiana. Hikes of 3/10 cents per gallon are due to general tightening of the market and a heavily increased demand because of abnormally cold weather. API statistics show a record drain on light heating oil stocks, with a 10,469,000-bbl supply cut in the week of December 16. This breaks previous withdrawal record of January, 1954.

★ ★ ★

Experimental turbine-powered car built by General Motors has been successfully tested and will be shown in January, officials say. Company says the car, called the Firebird II, will operate with "substantially" the same economy as present day automotive piston engines. No immediate production has been planned. All major automotive manufacturers have been experimenting with the gas turbine.

★ ★ ★

Steel production reached new peaks in mid-December with a record 2,421,000 tons turned out the week of December 19. Rate of operations at this time was 100.3 per cent. Forecasted rate was 99.3 per cent.

IDEA!

The Cycler sent out an opinion chart in a recent issue. The four-page pamphlet inserted in the magazine with a business reply envelop had pictures of each page in *The Cycler*. Under each picture were these possible answers: ☐ I read it; ☐ I didn't read it.

It was ☐ Good, ☐ Fair, ☐ Poor. Comments: .....

On the back of the pamphlet prizes amounting to $100 were offered for opinions on three stories. These were: The feature story best liked and why; the feature story liked least and why; and a suggested story to go in *The Cycler*.

Although not an entirely new idea, this certainly gives the readers of *The Cycler* an excellent opportunity to show what kind of a company magazine they want. It might be a good idea for periodic checking of readers.

A Canadian Crown company will be formed to build a difficult section of the 2200-mile east-west natural gas pipe line. Private financing has stymied Trans-Canada Pipe Line and delayed start of the $350,000,000 line by nearly a year. Federal and Ontario governments will finance the 675-mile northern Ontario stretch jointly, which Trans-Canada will buy when finances permit, says C. D. Howe, Canada's trade minister.

★ ★ ★

Cities Service and Gulf Oil com-panies have been the first to announce successful trimming of oil imports in the last quarter of 1955. Defense Mobilizer Arthur S. Flemming had requested the 7 per cent cut back. Cities Service reductions came from Kuwait.

★ ★ ★

Active rigs running broke all time records three weeks in a row in December for a peak of 3338, according to a count made by the American Association of Oilwell Drilling Contractors. In the last week of December, however, rotary rig activity fell to 3084, still nearly 200 rigs more than were running at the close of 1954. The final week's decrease was reflected in all of the 11 districts in the U. S. and Western Canada.

★ ★ ★

Unemployment taxes will be paid by an additional 300,000 small businesses in 1956. A new federal law cuts from 8 to 4 the minimum number of workers needed to become subject to the 3 per cent levy. All independent oil operators and small oil firms who fall into the new classification will also pay the corresponding state unemployment tax. The few states that didn't lower their coverage minimum to 4 to match the federal change, automatically tax any employer who pays the federal tax.

★ ★ ★

Gasoline and other oil products will soon be paying federal, state, and local sales taxes totalling $6 billion annually, the American Petroleum Institute reports. The tax take will hit the new mark if any new legislation, such as federal highway financing through gasoline levies, is passed in 1956. API tax economic bulletin says that taxes absorbed 6.2 per cent of each gross income dollar in 1954, compared with 4.4 per cent paid to stockholders.

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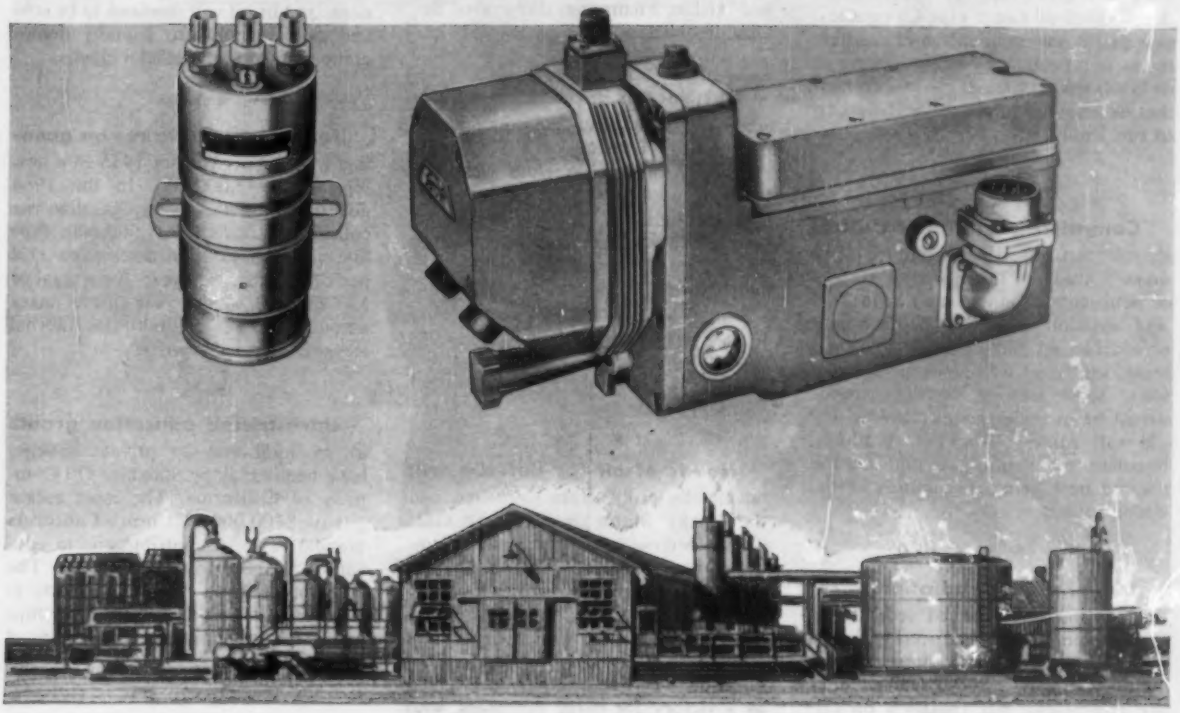
Presents a New Matched Ignition System



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The Bendix* LC Magneto has been engineered to meet the exacting requirements of the modern high-compression gas engines so widely used throughout the petroleum industry.

Because the Bendix LC is a completely new type of magneto, it incorporates the latest developments in materials, engineering, design and production techniques. The result is a matched ignition system—LC Magneto plus Bendix Hi-V Transformer Coils—that delivers ample voltage with greatly reduced maintenance costs.

For engines of 6 to 16 cylinders where top performance is a must, the new Bendix LC Magneto is the logical choice.

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Bendix
SCINTILLA DIVISION
Bendix AVIATION CORPORATION

To obtain more information on products advertised see page E-41

Eastern gas distributing companies claim they are not planning to spend any substantial amount of money fighting the gas legislation to free independent producers. W. E. Himsworth, assistant vice president of the Brooklyn Union Gas Company, speaking for the Council of Local Gas Companies, says that it has no intention of registering as an official lobby upon opening of its Washington office. It has been hinted that its activities might cause the group to run afoul U. S. lobbying laws.

★ ★ ★

Committee of the National Petroleum Council has been set up to make a study of underground storage of petroleum products such as jet fuel and aviation gasolines. Government is considering the possibility for defense, safety, as well as economic reasons. Most feasible "storage space" would be in underground caverns and old salt mines. Other oil products, liquefied petroleum gas, and natural gas are now being successfully stored underground.

★ ★ ★

Use of atomic radiation to refine gasoline, announced recently by Esso Research and Engineering, is just a portion of probing into nucleur energy uses applied to petroleum. There are indications that radiation on certain materials may produce more effective lubricating additives than are now possible. Gasoline is being processed by using radiation, under conditions that would normally prohibit its manufacture.

★ ★ ★

Steel prices are being juggled by several companies, generally resulting in higher prices for tubular goods. All butt-welded standard and line pipe were reduced about $2 a ton, although additional 6 per cent charges for less than one-ton orders have been established. One company has withdrawn its 5 per cent discount given to certain jobbers and fabricators.

★ ★ ★

More congressional hearings will be slated in the 15-year-old struggle to build a crude pipe line from West Texas to California, members of the House armed services subcommittee have indicated. The subcommittee is contesting the construction of the proposed $106,000,000 line by West Coast Pipeline Company, on the grounds that defense needs are not sufficient to require government financial aid being asked. Witnesses lined up for the new hearings include Arthur Radford, chairman of the Joint Chiefs of Staff and Arthur Flemming, director of defense mobilization.

★ ★ ★

Natural gas imports from Canada have been given government approval in a reversal of FPC policy. Pacific Northwest Pipeline Corporation will supply gas to the northwestern area through 955 miles of new lines costing $28,550,000. An estimated 300,000,000 cu ft of gas will enter the U. S. daily from Westcoast Transmission Company's line being laid south to the U. S.-Canadian border. This will supplement gas being brought into the Northwest from the San Juan and Permian Basins.

★ ★ ★

Needs of oil for defense will be met by crude from Canadian and the Rocky Mountains, not the Gulf Coast, Defense Mobilizer Arthur Flemming has indicated. Flemming has turned down tentative projects calling for government aid, on pipe lines of the American Pipe Line Corporation and Texas Eastern Transmission Corporation. The decision has been hailed as a victory for barge operators, who have been hauling the Gulf Coast oil.

IDEA!

Sometime ago THE PETROLEUM ENGINEER carried a suggestion that one of the best ways to publicize the oil industry might be by caravan.

This idea is proving worthwhile in other industries. Probably the most spectacular is General Motors Parade of Progress which is going from city to city in the United States and Canada. The show is operated by 70 young men, mostly just out of college or university. They drive the trucks on the road, put up the Aerodome tent and exhibit and give the lectures and demonstrations.

Viewers of the "Circus of Science" now number more than 6,000,000 persons. This is a considerable audience.

Salesmen, too, are finding the caravan or truck mounted display is advantageous in a number of products. This is true specially for such products as electronic computers which can hardly be sold from a briefcase.

"U. S. school of oil technology is the only one in the world, and we try to copy it," says Antonio J. Bermudez, director general of Pemex, Mexican government oil monopoly. Pemex has declined several attractive offers to do business with other nations, and its oil will continue to be sold and exported only to friendly democratic countries, the official claims.

★ ★ ★

Federal excise taxes on gasoline rose 13 per cent in 1955 to a new high of $947,000,000. In the 1954 governmental fiscal year, gasoline tax collections totaled $837,000,000. Pipe line oil transportation taxes were 31.4 per cent higher this year, for a total of $43,286,000. Last year these taxes amounted to $24,767,000, the Internal Revenue Service reports.

★ ★ ★

Unrestricted education grants to an additional 24 private colleges have been made by Standard Oil Company of California. The most recent gift of $100,000 will bring California Standard's 1956 contributions to education to more than $1,000,000. The company endows research projects at 8 universities, 43 technical fellowships and 216 undergraduate scholarships at some 100 colleges.

★ ★ ★

Headquarters building for Tulsa, Oklahoma, area activities of Shell Oil Company will soon begin construction. The new 10-story Shell Building, although privately owned, will house exploration and production offices for operations in Oklahoma, Kansas, Illinois, Indiana, Ohio, Michigan, Kentucky, Tennessee, and North Texas. Shell Pipe Line Corporation's communications offices and a Shell employment office will be housed in the new structure.

★ ★ ★

Termination of rule-making procedures concerning regulation of rates of independent producers for transportation and sale of natural gas has been announced by the FPC. "After full consideration of suggestions, comments, and recommendations submitted, it appears to the Commission that adoption of any standards, principles, or methods . . . is not appropriate or necessary in carrying out the provisions of the Natural Gas Act," the announcement reads.

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Petroleum Profile

George T. Naff

President, Texas Eastern Transmission Corporation

WHEN George T. Naff joined Texas Eastern Transmission Corporation in 1948 to work with his long time friend and business associate, Reginald Hargrove, a management team was re-established which at United Gas Corporation had worked together for many years. With Hargrove as president and Naff as first vice president the newly formed Texas Eastern was built in only a few short years to a position of prominence in the dynamic natural gas industry.

A tragic airplane accident in January 1954 took the lives of several outstanding Southwestern business men, among them the president of Texas Eastern. Shortly after, quiet mannered George Naff was called upon to succeed.

If this sudden change in top management caused any question about Texas Eastern's future growth, the answer came quickly. Before the end of year 1954, Texas Eastern had financed and constructed a $28 million pipe line from a point near Pittsburgh 265 miles to the New Jersey border, added flexibility to its system by construction of a 16-in. pipe line in Texas and had launched a diversification program to make the company one of the nation's largest common carriers of petroleum products.

If he had started out in his youth to educate himself for the Texas Eastern presidency, George Naff could hardly have selected a better curriculum than the one he followed. He earned a BS degree in engineering at Alabama Polytechnic Institute; entered University of Alabama Law School, where he was a Phi Beta Kappa, graduating in 1927.

For the next 20 years he divided his time about evenly between his law practice and work directly in the natural gas industry. His legal work with client companies such as United Gas drew him into the natural gas business and in 1931 he joined United where he served as vice president and general counsel.

The company which 54-year-old George Naff heads has grown into a half billion dollar enterprise in only 8 years. Formed to bid on the Big Inch and the Little Big Inch pipelines after the close of World War II, Texas Eastern's purchase of the lines was one of the rare transactions in which the nation's taxpayers received full return on money invested in a wartime emergency project. Texas Eastern's bid of $143,127,000, the highest of 13 submitted, was approximately what it had cost the government to build the two pipe lines.

In the summer of 1954 Texas Eastern took the initial steps to make the company one of the nation's largest common carriers of petroleum products. Naff feels that large scale operations in this "allied but different area of service" will add materially to the earning power of the company.

To carry out this reconversion and other projects now planned by Texas Eastern may require over a hundred million dollars of additional financing. Already Naff has been instrumental in the negotiations for the more than $400 million in financing which Texas Eastern has required since it was formed. A prized possession on his desk in Shreveport is a pen which has been used to sign approximately a billion dollars worth of securities which he has participated in negotiating at United and Texas Eastern.

The president of Texas Eastern has to be a traveling man. He deals with suppliers in the Southwest and with customers as far away as Boston. When expansion is undertaken his visits to Wall Street for financing are frequent, and since the company is subject to regulation by the Federal Power Commission he must often go to Washington to assist in clearance of projects there. To cover such territory he travels thousands of miles each year by plane.

A slight man with red hair and a reddish complexion, Naff is soft spoken with a touch of his native Louisiana in his voice. Despite his many years of activity among the nation's business leaders he retains a sincere attachment for the small town of Bastrop, Louisiana, which was his birthplace. This origin is often reflected in his homespun philosophy and ready, needling wit.

George Naff likes to make things grow. At present he is working on still other plans for expanding his company and broadening its activities. Despite these many responsibilities he finds time to supervise the cotton growing operations of the Northeast Louisiana plantation which has been in the hands of the Naff family for years.

Now the finest of needle valves is available

416 Stainless throughout...

In the Marsh Needle Valve, operating men found a valve that was better all the way through. Then came the call for a valve of like quality and precision for corrosion service . . . to be 416 stainless steel throughout.

The valve illustrated here is the answer. Like the parent valve, this new valve has safety and strength to spare . . . guaranteed for working pressures up to 10,000 psi . . . equally efficient and effective in any lower pressure range.

It too is machined from solid bar stock—in this case, 416 stainless steel. Its precision-ground and-machined stem is hardened 416 stainless. Packing is the special "Marpak" ring . . . one-piece, non-binding, long-lasting. So finely built is this needle throttling and cut-off valve that it can be easily throttled down to exceptionally fine regulation even on extreme pressure.

Read the list of features opposite. Then write for new bulletin No. NV-2 containing complete details.

The new all stainless valves (Series 1924) includes globe and angle patterns with double female connections in sizes ⅛", ¼", ⅜", ½", ¾", 1"; also globe and angle valves with male inlet and female outlet in sizes ¼" and ½".

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416 Stainless Steel ...all the way through!

- Body and stem guide machined from bar stock.
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Maximum Working Pressure 10,000 P.S.I.

Water, oil, gas or corrosive fluids not injurious to 416 stainless steel.

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giving you the EDGE

ON YOUNGSTOWN ELECTRIC WELD LINE PIPE

You "Get the Edge" when you buy Youngstown high strength line pipe. This is provided thru careful control of end preparation to give you accurately beveled ends that will line up quickly and easily and make a satisfactory joint.

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Youngstown Electric Weld Line Pipe in sizes 6" to 22" inclusive are produced in long lengths, with uniform walls.

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Arabian wildcat thrives on

"ONE-SOURCE" SERVICE

Wildcatting in distant places is always rugged work, but for one of National's customers operating in Dhofar, Arabia, the problems were unusually big. LST's and rafts had to beach thousands of tons of drilling equipment and other supplies from a freighter anchored off shore. A road had to be blasted over a 3,500-foot mountain range—monsoon-drenched and impassable all summer. Then sixty miles of desert to the drilling site, where it's 135 degrees in the afternoon. Yet the rig is up and drilling.

National Supply had the single responsibility of providing drilling equipment and all other supplies for this Arabian wildcat. We shipped one of our Type 80-B consolidated rigs and tons of drill pipe from Houston, along with trucks, jeeps, air-conditioned trailers, camp supplies, medicines, fuels—everything needed by crews located in the middle of a desert. To help insure efficiency in rigging-up, a National engineer traveled to and spent several days at the rig site.

Usually oil men have one of our 124 stores nearby where they can get everything from a can of paint to major equipment. Other times, as in Dhofar, we provide for their needs over long supply lines. In either case, operators know they can rely on the dependability of our one-source service, and the quality of our equipment.

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NATIONAL SUPPLY
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You move mud at low cost

with IDEAL® Slush Pumps!

When you install the Ideal Slush Pumps that are right for your volume and pressure needs, you're well on the way to a low cost mud system. All Ideal pumps, ruggedly built for dependable service under a great variety of drilling conditions, have the mechanical and hydraulic features that insure sound action, easy maintenance and long life.

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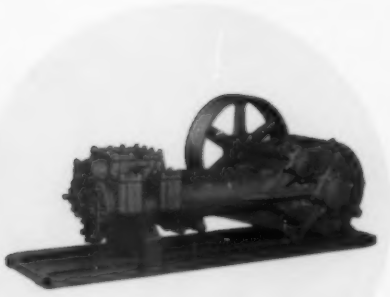
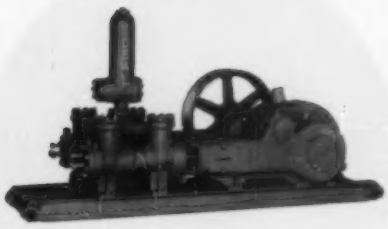
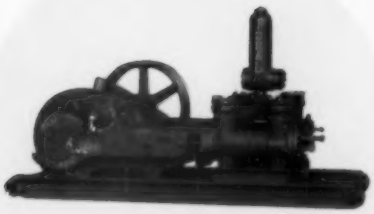
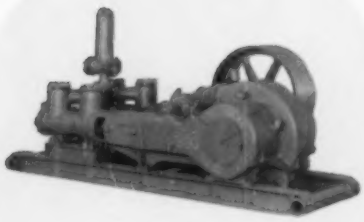
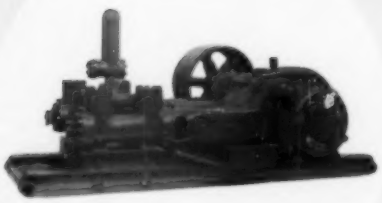
*Patented

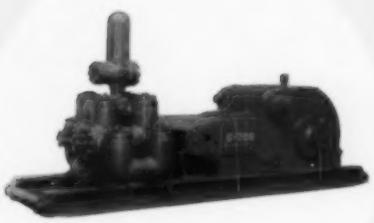


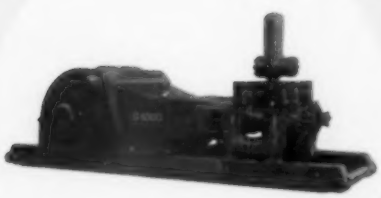












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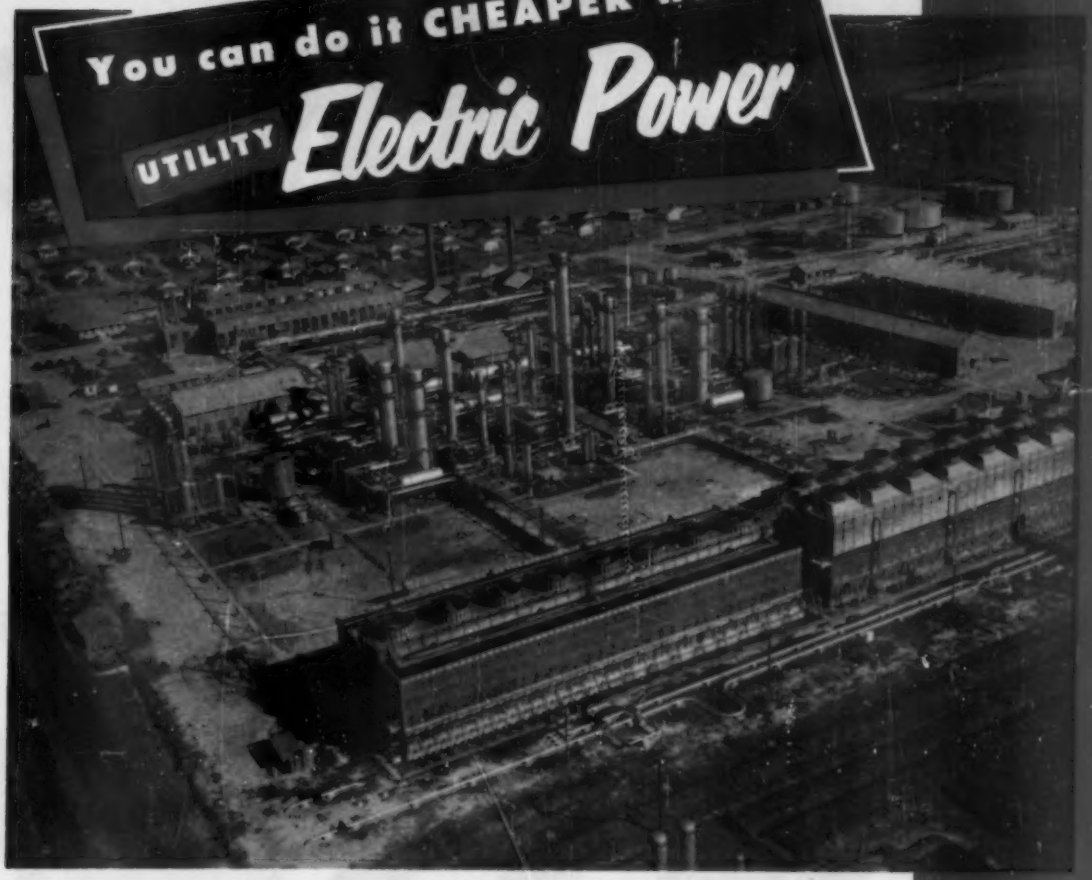

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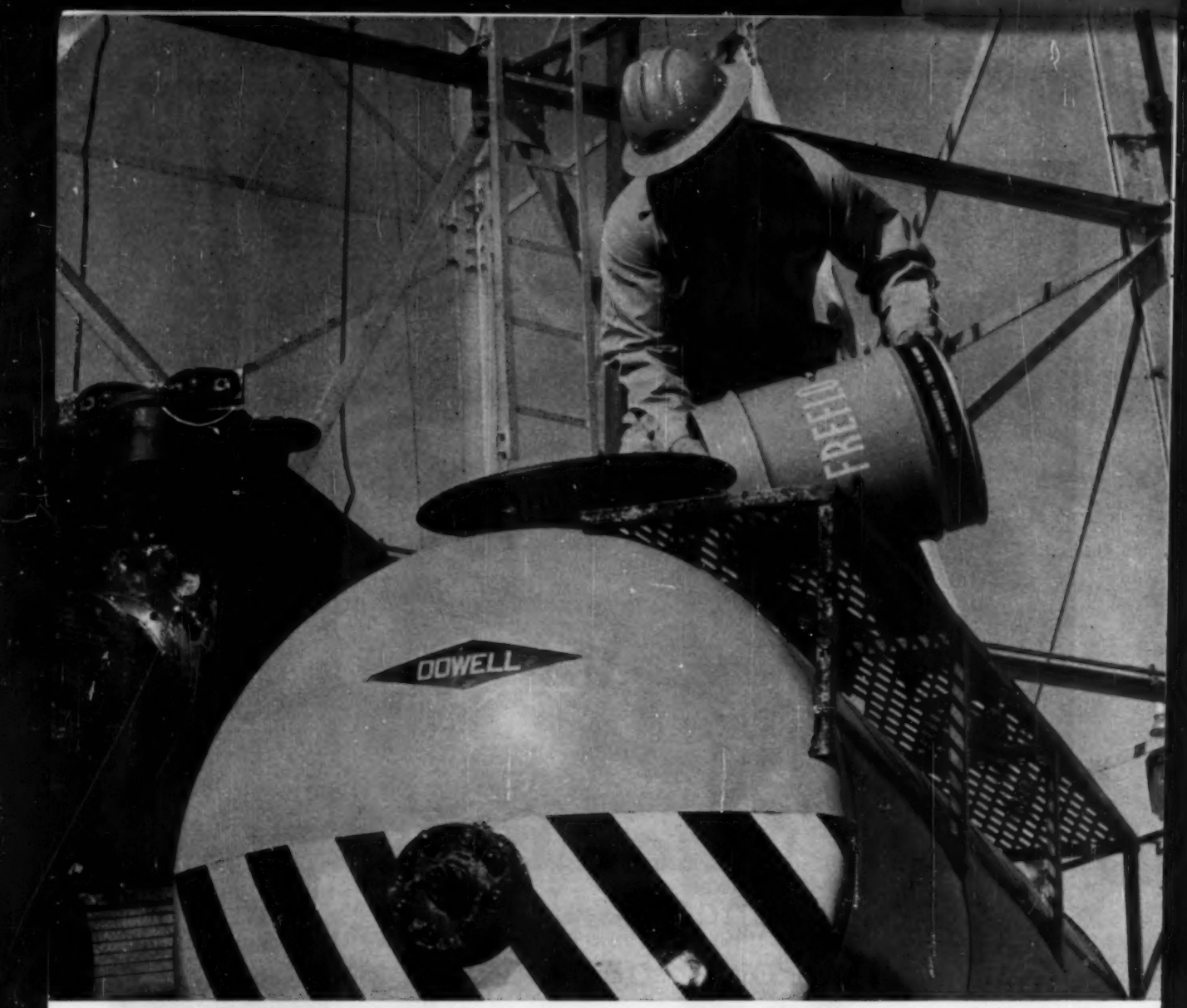

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services for the oil industry

DOWELL

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THIS YEAR OF PROSPERITY

The greatest gains — the greatest service are in the petroleum industry's future . . . requiring a $6.7 billion capital expenditure . . . There are dangerous hazards, too, in 1956

Ernestine Adams

ANY warning about business conditions in 1956 are drowned in a flood of optimistic forecasts. For the petroleum industry there seems little dissent from predictions that this year will be the greatest in demand and sales, in capital expenditures and earnings. Petroleum is fueling the greatest economic boom of all time.

With all this, the year could also be a dangerous one for the oil and gas industry. Federal controls, the cost-price squeeze, and taxation problems are immediate and threatening hazards to be met in the New Year. There are deep cross-currents, also, in the growth of automation, the shortage of engineers and scientists, the labor union drive, the uncertainties of a national election year.

Some forecasters say that demand for crude oil in the U. S. and for export will go to 9,000,000 bbl a day in the coming year. It is the concensus that the estimated 8 per cent jump in 1955 demand over 1954, will be followed by a more "normal" expansion of about 4 or 5 per cent in 1956. IPAA estimate is 3.4 per cent increase.

There are several reasons why this estimate may be low. First, the "Geneva Peace" warmth has chilled off to zero, resulting in a proposed increase in military expenditures — which means larger requirements for oil products.

Second, this will very likely be a record highway construction year. Some increased federal financing of highways is in the making and increased state and local government spending is always concerned with new roads. This not only means greater use of highways by oil-powered vehicles, but substantial supplies are required for construction.

Third, amazing sales effort of automotive industry and its progress in adding second and third cars to the family in 1955 is a goal to shoot for in 1956. The dealers may get closer than most believe possible. Only a few think they can do as well but they certainly do not expect a large drop in sales. The most pessimistic forecast is for 10 per cent less sales and you must remember 7,300,000 automobiles were sold in 1955.

Last, new housing and commercial construction has held on with surprising tenaciousness. Where new housing construction may come down, other types of construction seem set to make another record.

Capital expenditures for the oil industry will hit a new high; the U. S. industry will go over the $6.65 billion mark for capital expansion here and abroad. This is based on figures of the 15 companies which supplied estimates of investment in each division for 1956. As most companies capitalize intangible development cost of producing wells and dry holes, these are included in expenditures.

Indicated expenditures by U. S. companies in domestic and world operations run something like this, according to these early estimates:

Production	**$4,250 million**
Manufacturing	**1,200 million**
Transportation	**500 million**
Marketing	**700 million**
TOTAL CAPITAL EXPENDITURES	**$6,650 million**

In most instances no attempt was made to divide domestic and foreign expenditures. Some stated that this was flexible and rested upon future events.

Of the $1.2 billion Standard Oil Company (New Jersey) and its associates plan to invest, only $475 million will be spent in the U. S. Other companies are spending more on world operations so it is reasonable to conclude that not more than $5 billion will be used for modernizing and expanding domestic facilities and adding to reserves, with the balance invested in foreign countries.

Total increase of capital expenditures in 1956 over 1955 is estimated at about 11 per cent. For 1955 capital expenditures were forecast at $5¼ to $5½ billion (The Petroleum Engineer, May, 1955) but boom times obviously pushed the sum higher and the total for domestic and foreign investment probably went over $6 billion. Comparison of actual estimates of 21 companies showed a 14 per cent increase in 1956 over 1955 capital expenditures.

Very few companies expect to borrow to finance expansion although several said they would be prepared to do so if needed. Most capital is supplied by depreciation and depletion allowances and retained earnings.

There will undoubtedly be cutbacks and changes in this huge development program if the industry cannot solve satisfactorily these four vital problems:

These are some of the problems to be met in the early future:

FPC CONTROL

One would have to be clairvoyant to decide which is the most important petroleum problem. The Fulbright bill, however, will certainly come first on the calendar.

The House passed the Harris bill, which exempts independent natural gas producers from FPC control, by only a 6-vote margin — 209 to 203. The similar Fulbright bill will be presented in the Senate early in the 1956 session.

The debate on the proposition has been intense. Opposition is centered in the North and East where most of the natural gas consumed comes from the Southwest. Politicians have taken up the argument and obscured the important question at stake: Which is best for the producer and the consumer — not which is best for one *or* the other. A solution unfair to either serves neither.

A free market provides the soundest method for arriving at the price of any item. It is the democracy of economics. Any state control of price is an economic autocracy no matter how wisely administered. The consumer as well as the producer is safer over the long period when price controls are limited to regulations of monopoly, such as public utilities.

One of the greatest drawbacks of the government enterprise system is that prices of goods are unrealistic. No mathematical formula can determine what a product is worth to buyers until it is introduced into a free market. Nothing except actual experience in buying and selling a product in open market can achieve the delicate balance of changeable supply and demand and cost and price.

Every item taken out of the free market makes our economy that much more slow and inflexible. The red tape involved in autocratic or bureaucratic price-setting is costly in effort and personnel and results in a time lag that is deadly to efficient operations in the office and in the field.

Natural gas sales and pipe line construction will depend heavily on the passage of the Fulbright bill.

DEPLETION TAX ALLOWANCE

If you had to point to one event that gave the U.S. the cheapest energy of any nation — a strong base for its economic progress — you'd have a hard time finding any better one than the passage of the percentage depletion tax allowance bill in 1926.

There had been special allowances since 1913 for oil and gas production but it was slow and mostly guesswork. A new field was evaluated and the sum named was capital investment to be depreciated. A similar arrangement is possible today if an owner sells his producing property and takes capital gains tax. This procedure is frequently used by field discoverers.

With the percentage depletion tax allowance the owner knows where he stands. He will not have to pay taxes on funds he needs to replace his oil reserves and is therefore willing to take greater risks in seeking new production.

The industry has used the allowance to good advantage. In the first half of the 20th century it provided the United States with a cheap fluid energy in quantities never before known. It fueled two World War military victories. No one knows how this could have been done without the sums made available by the depletion tax allowance.

The year brings again the perennial objection—not to a depletion tax allowance but to the amount. The oil industry, when it occasionally goes on the offensive, says the allowance should be higher. The so-called "liberal" group, led by Senator Paul H. Douglas (D. Ill.), wants to lower the 27½ per cent allowed.

The debate goes on. It is encouraging to remember that the radical as well as the conservative Congresses since 1926 have stood on the 27½ per cent depletion allowance. But it is never any cinch. The whole complicated process has to be explained again and again.

COST-PRICE SQUEEZE

Everything goes up except the price of crude oil and oil products. IPAA's Cost Study Committee reported last October that there had been no significant change in the national average price of crude oil in the U. S. since June 15, 1953. Compared to this date, average unit costs in 1955 for equipment, materials, services and wages increased 10 per cent. Considering increased volume of exploration and drilling, total expenditures for finding and developing crude oil in the U. S. were about 20 per cent more in October, 1955.

Technical improvements and greater volume have concealed the cost increase. Oil and gas production in times of generally rising costs is at a disadvantage because of the time that elapses between discovery and marketing. Replacement costs are always higher and profit margins narrow when they should hold steady to provide for new resources.

More attention was being paid to the lag in price at the end of 1955. Another rise in price of steel and other supplies was in the making. Shipping rates had rocketed and had roughened up distribution. A number of producing companies found profits unsatisfactory in a booming year.

For the expansion in 1956 and to keep up with a steadily increasing demand, the petroleum industry needed an upward adjustment in price of crude oil and petroleum products.

BETTER UNDERSTANDING

A clearer idea of the oil and gas industry's many and complex problems is a vital and continuous problem. Many other problems can be traced to lack of understanding. Right now our bitterest controversies seem to be within the industry.

Suppose, for instance, the gas utilities executives who lead the opposition to the Fulbright Bill could tour the gas production centers and hear first hand of the experiences of those who seek and develop natural gas resources. They would have a much better idea of what they were buying. They have problems, too, of low sales per customer where space heating is predominantly coal and fuel oil. We battle with statistics that cannot tell the whole story.

Price wars in various communities need a calm and sympathetic approach, which is admittedly hard to find when you're in the midst of one. The import question is not simply: "Does it hurt me?" The answer must reconcile opposing forces.

We refer often to our public relations. Actually when the service station helper and the gas meter reader knows something about the petroleum industry and how it works, most of the nation will go along.

Leaders in the petroleum industry predict a prosperous year in 1956

CAPITAL INVESTMENTS WILL EQUAL OR EXCEED 1955 PROGRAM

Capital Expenditures to Be Higher

K. S. Adams
Chairman of the Board
Phillips Petroleum Company

CAPITAL expenditures for Phillips Petroleum Company 1955 are estimated to between $165,000,000 and $170,000,000, or 25 to 30 million dollars higher than in the previous year. It appears that the 1955 division of capital expenditures is about the same as in the past.

We anticipate that capital expenditures in 1956 will exceed the amounts for 1955.

It is further anticipated that there will be an increase in sales for the oil industry during the year 1956 over the year 1955, and it is natural to assume that earnings in the oil industry will be greater in 1956 than in the past year.

Capital Outlay to Average $5 Billion a Year

Robert E. Wilson
Chairman of the Board
Standard Oil Co. (Indiana)

AS for the prospects of the industry, it is easy to be a prophet for ever-growing volume. If the weather is normal the over-all increase in domestic demand for this year should run close to 7 per cent, making up for an abnormally small gain last year. The gain over the next 15 years should total at least 40 per cent. There will probably be a gradual reduction in the rate of increase for residual and distillate fuels, but the rate of gain for natural gas, LPG, and petrochemicals should continue well above average.

Capital requirements will continue to be heavy. I think they will continue to average around $5 billion per year.

The general crude price structure should certainly hold, but I do not expect any general increase in the near future, even thought both finding and operating costs are continuing to rise. Stocks of heavy fuel oil are low and those of gasoline not far out of line, but distillate stocks seem too large unless we should have an unusually severe winter.

Appropriations Increased for 1956

M. S. Beringer
President
British American Oil Ltd.

BRITISH American's total capital expenditures have averaged about $31.6 million yearly for the past 5 years. Expenditures in 1956 will be on a somewhat larger scale but will not depart noticeably from the pattern established.

Approximately the same appropriations among the various company operations will be made and no appreciable reduction or increase is contemplated for any specific department or geographical area.

The company plans to continue active participation in exploration and production activities both in western Canada and in the United States.

For the marketing department, the importance of personnel training will continue to be emphasized to enable the sales force to meet the challenge of stiffer sales competition. For the same reason, the company will also acquire, wherever possible, locations for future retail outlet development.

The manufacturing department will implement its ambitious products improvement program of catalytic reforming installations. During 1955, the company's first reforming unit went into operation at the refinery at Calgary and at the year's end the cat reformer at the Montreal East refinery was completed. Similar installations at other refineries are in the planning stage.

Maintains Same Expansion Rate

Robert G. Dunlop
President
Sun Oil Company

SUN Oil Company in 1956 will continue the aggressive pace of expansion that has been characteristic of its operation in the postwar years.

Capital expenditures will approximately match those of 1955, when $75,900,000 was put into new facilities and intangible developments costs of $34,200,000 were incurred in the search for new oil.

In 1955, the company's capital expenditures in the U.S. and Canada included $30,700,000 for production facilities, $29,000,000 for manufacturing, $6,100,000 for transportation and $9,400,000 for marketing.

Production and transportation expenditures in 1956 will be essentially unchanged, while marketing expenditures will increase slightly and manufacturing expenditures decline slightly, as compared with 1955.

Sun's 1956 expenditures on foreign operations, excluding Canada, cannot be determined at this time. They are dependent upon the outcome of current negotiations for concessions in areas in which the company is interested.

Sun is planning for 1956 on the assumption that there will be a continued high level of economic activity in the country as a whole, at least through the first six months of the year, and that domestic demand for petroleum will increase from 4 to 5 per cent over 1955.

$4000 Needed per Barrel of Oil Found

M. J. Rathbone
President
Standard Oil Co. (New Jersey)

IN the United States, it seems quite likely that the world's greatest oil consumer will be using 60 per cent more oil 20 years from today. In 1955, thus far, the high levels of economic activity and the near normal weather encountered last winter have meant an industry growth in demand for products so far of around 8 per cent. This growth has been shared by essentially all products. All Jersey's domestic affiliates have shared in this growth.

For Jersey affiliates to keep pace with this growing demand calls for tremendous capital investments. We estimate, for example, that each new barrel of oil found and brought to market today requires an investment of about $4,000, representing a world-wide average, and on that basis it does not take long to arrive at impressive investment figures. We have

invested $6 billion since World War II, for example—and it will undoubtedly be necessary to keep on making investments of even greater magnitude during future years. To pay for some of the projects, in 1956 Jersey's consolidated affiliates are planning capital investments and expenditures of about $1.1 billion; and Jersey's share of expenditures by companies in which it has one-half interest or less will bring the total to $1.2 billion. This is the largest amount ever budgeted by our affiliates in any one year on exploration and production operations, and refining, transportation, and marketing facilities.

Of the amount for consolidated companies, $950 million or 86 per cent, will be spent within the Western Hemisphere. Forty-three per cent of the consolidated total, or $475 million, will be spent in the United States. The remaining 14 per cent of the consolidated total, amounting to $150 million will be spent chiefly in Western Europe, the United Kingdom, and North Africa. Added to this, of course, are the capital investments which will be made by the non-consolidated companies in that area, which will bring Jersey's total investment in the Eastern Hemisphere for 1956 to about a quarter of a billion dollars. About one-half of the $1.2 billion outlay will go for exploration and production, about one-fourth for refining facilities, and the remaining fourth for marketing and transportation. This ratio will apply pretty closely in both main geographical areas.

Each affiliate tries to pay its own way and make capital investments out of depreciation plus retained earnings after dividends.

Free World Demand Continues Steady Rise

T. S. Petersen
President
Standard Oil Co. of Cal.

THE domestic petroleum industry in 1955 experienced a substantial 7 per cent growth in demand for its products as a result of the strong recovery in business from the mild decline of 1954. Colder winter seasons than last year also contributed to the increase by stimulating sales of distillate fuel oils for heating.

Abroad, the industry enjoyed an even greater increase in demand—11 per cent—reflecting the continued expansion of foreign economies and the inability of Western Europe's coal industry to meet that region's growing fuel requirements.

Prospects for 1956 point to further sustained growth of the U.S. and Free Foreign World economies, though at somewhat lower percentage increases than in 1955.

Domestic demand for petroleum in this country is forecast at 4 per cent higher, with a 4½ per cent increase expected in gasoline demand. In crude oil production, this should be reflected in a 225,000 bbl-a-day increase over 1955, with an aggregate of 7,000,000 bbl-a-day, setting an all-time record.

Elsewhere in the Free World, total petroleum demand is expected to rise about 9½ per cent, with the emphasis on the heavier fuels, which are now figuring more and more importantly in the industrial development of Western Europe.

Under the circumstances, the industry feels justified in proceeding with large-scale capital expenditures, in our case on about the same scale as in 1955. A substantial proportion of our outlay for these purposes will be allocated to further exploration and development of offshore oil, which is already proving a valuable asset to the industry.

Long Range Future Bright

D. A. McGee
President
Kerr-McGee Oil Industries, Inc.

IT is energy controlled by man that is the basis of our civilization. The rate at which the use of energy has accelerated during the past 50 years is almost fantastic. The demand for oil and gas, which now supply almost 70 per cent of the energy requirements of the United States, is increasing at an even greater rate outside our country. It has been estimated that the requirement for energy in the United States will approximately double by 1975. When an industry is so fundamental to our way of life and in addition has such a sharply rising demand for its products, its long range future can only be bright.

Nuclear energy — fusion and fission — which a few years ago appeared as a possible competitor to our oil and gas business, may now be seen in a better perspective as a supplemental source of energy that may be needed within the next few decades.

Increase Rate Back to "Normal"

Henderson Supplee, Jr.
President
The Atlantic Refining Company

OUR present forecast is that domestic demand for oil products will increase again in 1956, but at a more "normal" rate than in 1955. Specifically, whereas total domestic demand in 1955 was about 7 per cent higher than in 1954, we look for an increase in 1956 of about 4 per cent over 1955.

Since exports are likely to drop by 10 per cent or more as the result of the growth in refining capacities abroad, total demand on the United States industry will probably increase next year by something less than 4 per cent —perhaps about 3.5 per cent.

This forecast is based on the expectation that general economic activity in 1956 will average a little higher than in 1955. Supplies of oil products should be fully adequate to meet anticipated demands next year. Except for minor short-term fluctuations, we do not expect to see much change in the oil price picture.

Looks to Large Demand in 1956

Wm. Wallace Main, Jr.
President
Bishop Oil Company

WE expect that the demand for crude oil in 1956 will rise approximately 10 per cent above that in 1955. We expect also that prices should hold firm during the year stimulating higher profits in 1956.

Petroleum supply and demand should be considered on a continental basis in overall planning of defense and other needs. Encouragement should be given to the development of Canadian reserves as well as the United States.

PROSPECTS GOOD – ARE PRODUCT INVENTORIES TOO HIGH?

Greatest Growth Now Approaching

Augustus C. Long
President
The Texas Company

WE in The Texas Company feel that the petroleum industry is now approaching the period of its greatest growth and service. Domestic consumption of petroleum products in 1956 will increase almost 4.5 per cent over 1955, reaching about 8,660,000 bbl a day. Free-world foreign demand will run close to 6,240,000 bbl a day.

To maintain our position in the broad field of energy supply, we are putting tremendous stress on research and development.

Capital expenditures in 1955 will be about $295 million. Since World War II Texaco has invested $2 billion in property, plant and equipment.

Our plans, as presently projected, call for an expenditure of more than $1½ billion during this period to improve and expand our facilities all along the line. For 1956 the capital investment budget is a record $325 million. This does not include our substantial equity in the investment budgets of companies in which we have a 50 per cent or less interest. The company expects to generate these funds out of depreciation and retained earnings. If conditions should develop that make this impractical, however, we will not hesitate to seek outside financing.

Expects Peak About Mid-Year

J. C. Donnell, II
President
The Ohio Oil Company

PROSPECTS for general business conditions in 1956 are good. The usual indexes for the year should average slightly higher than they did in 1955 but a change in direction is likely, we believe.

Briefly, we expect industrial activity to peak out in the middle of the year and then follow with a gradual decline. On this basis, we estimate the demand for petroleum in the United States will increase between 4½ and 5 per cent over the estimates for 1955.

High Product Inventories Are Threat

L. F. McCollum
President
Continental Oil Company

AS measured by gross national product, the level of general business in the last quarter of 1955 will reach an all-time high. This should carry over well into 1956, with the better quarters coming early in the year, as opposed to the steady build-up of 1955. In total, the year 1956 is expected to be somewhat better than 1955. Buying by individuals should maintain its upward trend of recent years even though purchases of automobiles will undoubtedly lag behind 1955 levels.

As a corollary to this increase in general business activity it is also anticipated that total petroleum demand will approximate 9 million barrels a day during 1956, an increase of 3.7 per cent over 1955, while domestic demand should increase about 4 per cent.

Of the many problems facing the petroleum industry as we enter 1956, probably the first to be faced is the threat of excessive product inventories due to the high level of refinery runs. Gasoline stocks are behaving in a manner similar to 1953 which led to critical problems during the 1954 gasoline season. Distillate inventories at the end of November were 10 million barrels greater than a year ago with only the hope of a cold winter to move these stocks by spring. In spite of a strong market, residual stocks east of California are running well above year ago levels.

Refinery runs could be cut back without immediate curtailment of crude production as crude inventories are well below those of previous years. Though our dynamic industry is noted for its record breaking growth, all-time high levels of inventories are not a record of which we can be proud.

The problems of the industry are aggravated by the import situation, a satisfactory solution to which has not yet been found. Continuing efforts, by all concerned with this issue, are needed in order to achieve a reasonable balance between imports and domestic supply.

Moderation and sound business judgment will be required by all segments of the industry throughout 1956.

Believes Increase Will Be Slightly Higher

R. L. Tollett
President
Cosden Petroleum Corporation

OVER the first half of 1956, our prospects at Cosden are good, because all of our aviation gasoline production is sold, as well as most of our jet fuel production. Furthermore, we expect our asphalt business to be good and our income from sales of crude oil is increasing.

Our 1956 capital budget is the largest in our history. Two-thirds will be used to make additions to the Big Spring refinery and one-third for exploration and development.

With respect to the whole domestic industry, I believe that earnings will be slightly above the level of 1955.

Free World Uses 14½ Million Bbl Daily

S. A. Swensrud
Chairman of Board
Gulf Oil Corporation

GULF Oil Company's capital expenditures for plant and related assets in 1955 will be in the neighborhood of $280 million, about 60 per cent of which is applicable to producing operations. Our budget for 1956 is still being studied. However, indications are that such outlays will probably be greater than in 1955 or any previous year.

The petroleum industry must now keep pace with a consumption rate of about 8½ million barrels of oil daily in the U.S. and 6 million in the rest of the free world, or 14½ million barrels daily world-wide. World consumption will increase to 22-23 million barrels a day by 1965, and by another 10 years to something like 30 million barrels daily. By that time consumption outside this country will probably surpass that of the United States.

COST-PRICE SQUEEZE IS ONE PROBLEM THAT MUST BE SOLVED

Price of Crude Oil Lags Behind Costs

Walter S. Hallanan
President
Plymouth Oil Company

THERE is every reason to believe that 1956 will establish another all-time record level for consumption of petroleum products. There is no reason to expect any slackening in the rate of increased demand.

The domestic oil industry is prepared to meet this increase just as throughout its history it has met all of the nation's demands in both peace and war. It has a reserve productive capacity that is more than adquate and its house is also in order with respect to refining, transportation and distribution facilities.

Unless there is a realistic adjustment in the price of crude, however, it cannot be expected that the industry can continue indefinitely to maintain adequate reserves and surplus productive capacity. Those companies which depend entirely upon domestic production are able to show a profit now only because they are producing oil that was discovered and developed at the much lower cost which prevailed from 10 to 20 years ago.

The price of crude has lagged far behind the tremendously increased cost of finding new reserves. It is simple economics that if this gap is not closed, the nation will pay the penalty of declining reserves and productive capacity. That situation would be calamitous from the standpoint of national defense and maintaining an over-all healthy economy.

Highway Needs Are Plus Factor

Glenn E. Nielson
President
Husky Oil Company

There is general agreement that, in 1956, the national economy will continue to maintain the high level of activity that has marked its performance during the past twelve months. Even the most gloomy prophets appear satisfied that any dip in the economy, if it should come, would be limited both in degree and in duration.

It seems reasonably safe to assume, then, that the outlook is good for the petroleum industry in 1956. The *rate of increase* in consumption of petroleum products that has prevailed generally for some time may not continue to be as steep as heretofore. Nevertheless, with the national economy sound and the nation moving steadily toward even higher levels of mechanization, a continued increase in consumption of petroleum products does not appear to be at all unlikely.

Certain bugaboos that have plagued the industry in years past are always factors to be reckoned with. Possible oversupply of petroleum is one of these. However, if we assume that the national economy will continue at the approximate level of 1955 and that crude imports are not materially increased, the prospects seem bright that any serious problem of over-supply can be avoided.

Severe restrictive legislation, which has on occasion upset the industry's performance, does not appear on the horizon. Certainly no need exists for any such action and no rumblings of any such action are audible save from the same quarters which always hold the petroleum industry in their gun-sights as a potential target.

One plus factor in the general outlook for the industry is the increased attention being given to the pressing highway needs of the nation. A tremendous back-log of needed highway construction has been built up during the great expansion of the U. S. economy that has taken place in the past several years. For this reason we can expect the good asphalt market which prevailed in 1955 to continue on throughout the new year. In addition, Congress seems almost certain to act during the coming session on a long-range highway building and modernization program. Such action, properly implemented, could possibly have a stimulating effect on highway construction activity even before the end of 1956.

The facts supporting the use of asphalt in this highway system expansion are convincing. Exclusive of the cost of building a good base, which is needed for either asphalt or cement highways, two miles of asphalt surfacing can be built for the cost of one mile of cement. Furthermore, actual tests have proved that an asphalt road will carry greater loads with less maintenance cost per year. And, finally, asphalt roads offer greater safety and greater length of life as a highway surfacing material.

Nuclear Research Significant to Oil Industry

B. B. Jennings
Chairman of the Board
Socony Mobil Oil Company

IF current business predictions hold true, next year will be even more challenging for the petroleum industry than 1955 has been; competition on the sales level will be sharper, and—of probably greater importance—efforts in the field of research to develop new and better products and processes will be intensified.

Research has always played a vital role in the oil business, but it is particularly significant that this past year has seen a number of oil companies, Socony Mobil among them, committed to large nuclear research programs. While it is doubtful that this new area of inquiry and experimentation will begin to bear fruit for some time, it is none the less safe to say that the very fact of its existence will have great and immediate impact on research programs generally. Certainly the entry of the petroleum industry into the field of nuclear research not only augurs well for the consuming public but, in addition, it testifies to the vision of the industry itself.

Instead of drawing back from this newest and most awesome of energy sources, the industry has taken the long view and welcomed it as a partner in a common task. One doesn't go too far out on a limb to predict that this attitude cannot but in the long run prove of great benefit to the industry and to all of mankind.

Outlook Seen for 3½% Gain This Year

Rawleigh Warner
Chairman of Board
The Pure Oil Company

ON a volume basis, 1956 should be better than 1955 by at least 3½ per cent — in short, domestic demand for crude oil will run around 8,650,000 bbl a day, an all-time high.

* * *

THE *Petroleum* ENGINEER

Exploration
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Giant Model Slush Pump

with Revolutionary New Features!

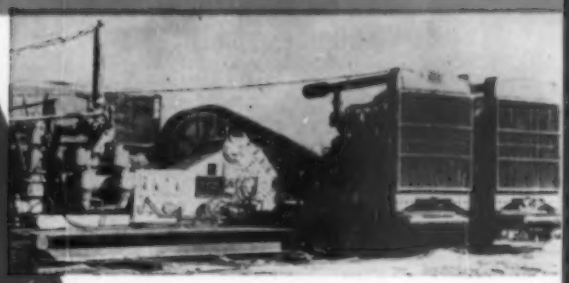

Photo of Wilson Pump on location. Note size in comparison to the engines. This pump is compact in design and construction, with the capability of handling high volumes, pressures and HP capacity.

MAXIMUM LINER BORE AND STROKE 7½" x 14", WITH SPEEDS OF 80 TO 90 STROKES PER MINUTE

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DIAMOND ROLLER CHAIN DRIVE — FABRICATED STEEL CASE

★

SKF SELF-ALIGNING ROLLER BEARING CRANKSHAFT

★

LIGHT WEIGHT — HIGH SPEED — HIGH CAPACITY

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QUICK REMOVABLE VALVE COVERS

★

EASILY REMOVABLE VALVE SEATS THAT WILL NOT "WASH BY"

★

QUICK REMOVABLE CYLINDER HEADS

★

LINER REMOVING TOOL WILL REMOVE LINER IN FEW MINUTES

★

TAPERED THREAD ON END OF RODS. ABSOLUTELY TIGHT WHEN INSTALLED, YET EASILY AND QUICKLY REMOVED

★

COARSE ACME THREAD ROD PACKING BOX, PINION ADJUSTED

★

PRESSURE LUBRICATION ON ALL MOVING PARTS BY OIL PUMP

★

ALL BEARINGS SELF-ALIGNING TYPE, SKF SELF-ALIGNING ROLLER EXCEPT SELF-ALIGNING BRONZE WRIST PIN BEARING

★

NEW TYPE CRANK CONSTRUCTION, HIGHER EFFICIENCY, AND LIGHTER THAN ECCENTRIC

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MARVELOUS NEW SUCTION FLOW EQUALIZER

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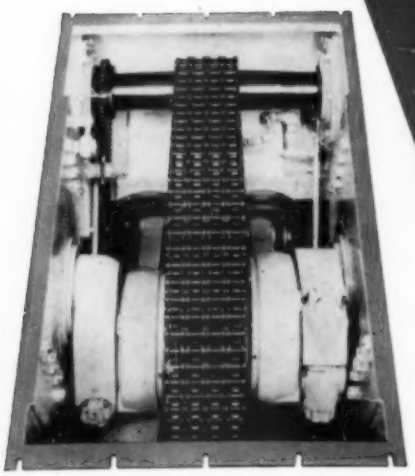

Wilson Revolutionary Chain Drive means no gears. This adds greatly to the efficiency and is proof against damage which was previously caused by gear teeth breakage.

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Write Us for Details of This Unusual New Pump

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OUT THERE...

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And with this extra power, remember, you get all the *other* extras of Lane-Wells perforating:

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DEPTH MEASURE ACCURACY with Lane-Wells famous depth measuring system.

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tests prove its tremendous penetration!

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Exploration, Drilling, Producing

Libyan Exploration Set

Texas Gulf Producing Company was awarded a 5,000,000-acre exploration concession in Libya in the name of its subsidiary, the Libyan American Oil Company. Drilling operations will begin in April, officials say.

Agreement with the Libyan government calls for an eighth of all oil and gas up to 15,000 bbl daily and a share in 50 per cent of the net profits of all production above that figure.

Special land concessions for oil exploration, totalling slightly less than 35,000,000 acres, have been granted to Continental Oil Company, Ohio Oil Company and Amerada Petroleum Corporation by the United Kingdom of Libya.

Each company will participate to the extent of ⅓ interest in all concessions obtained by any of them or their subsidiaries in Libya.

★ ★ ★

Turkey Grants Permit

D. D. Feldman Oil & Gas, Jersey Standard, and the Turkish Petroleum Company have been granted exploration permits in Turkey. Feldman, a Dallas, Texas, independent, has been issued permits on three areas.

All three companies have been active in Turkey for some time. Turkish Petroleum has production and refinery properties. Jersey Standard is now doing seismic work.

Over 180 applications for exploration permits are now pending before the Turkish Petroleum Administration.

★ ★ ★

Stripper Survey Complete

When is a stripper well not a stripper well? When the well is waterflooded is the answer in Arkansas and California. In these two states average stripper production is above the 10-barrell maximum that identifies the stripper well. Arkansas strippers averaged 11.03 bbl per day and California's wells averaged 10.32 bbl per day last year.

Nearly two-thirds of the oil now being produced by stripper wells will be recovered only by secondary recovery methods, the National Stripper Well Survey has indicated. Total recoverable crude from the nations 340,376 stripper wells has been estimated at 7,714,410,000 bbl. Over four billion barrels can only be recovered through secondary recovery.

Pennsylvania recorded 72,862 wells producing an average of 0.36 bbl daily. Texas listed 55,590 strippers averaging 4.81 bbl daily.

The stripper well survey was made by the Interstate Oil Compact Commission in cooperation with the Independent Petroleum Association of America and the National Stripper Well Association.

★ ★ ★

Another Oil Show

Houston, Texas, has accelerated plans for its World Oil Exposition for a showing date late in April. Originally not scheduled until 1957, the oil show held in 1955 attracted sufficient interest to warrant a 1956 exposition.

This year's show, according to Duane Ellis, president of last year's International Oil Exposition in Houston, will be slanted more toward the general public. Over 50 exhibitors have been scheduled for the World Oil show. Proceeds of the show go to charity, Ellis states.

★ ★ ★

Seismic Permit Let

Standard Oil Company of California has received permission from the state lands commission to do offshore seismic exploration along a strip of about 250 miles of state owned offshore lands. The permit has been granted for a 90-day period and extends from Point Arguello, Santa Barbara County, to Dana Point, Orange County.

The state commission deleted a clause, usually required, calling for a "confidential review" of exploration results.

★ ★ ★

COC Organizes Production

Canadian Oil Companies, Ltd., has set up its new producing department with headquarters at Calgary, Alberta. Executives of Anglo-Canadian Oil Company, recently merged into Canadian Oil, will head the department.

The purchase, which brought the company into the drilling and production business, gave Canadian Oil more than 175 producing oil and gas wells in Alberta and lease interests in Alberta, British Columbia, Saskatchewan, Manitoba and in the Williston Basin in the U. S.

J. B. Webb, of Anglo-Canadian, has been appointed producing and exploration department manager.

Penn Crudes Get Hike

Pennsylvania grade crude oil has received four price increases in 1955 — two in November. Last hike, announced by the South Penn Oil Company's Joseph Seep Purchasing Agency, boosted the value of major grades another 10 cents per bbl.

New prices for Bradford district oil is $3.85 per barrel; middle district grade has been revalued at $3.72, $3.43 for Southwest, and $3.31 for Eureka. The agency posts no prices for Alleghany, Buckeye or Zanesville grades.

On November 1 a hike of 15 cents per barrel was given the Penn grades by the same group.

★ ★ ★

Yeman Open to Oil

Door to oil exploration in Yeman has been opened to an independent firm known as the Yeman Development Company. A 30-year concession has been granted the company on some 40,000 square miles to explore and develop oil and mineral resources.

The company will divide all net profits on a 50-50 basis with the Yeman government. The contract may be voided in six years if no petroleum or minerals have been found to exist in commercial quantity, and is the first such agreement made with any group in the history of that nation.

Yeman is situated on the southern tip of the Arabian Peninsula.

★ ★ ★

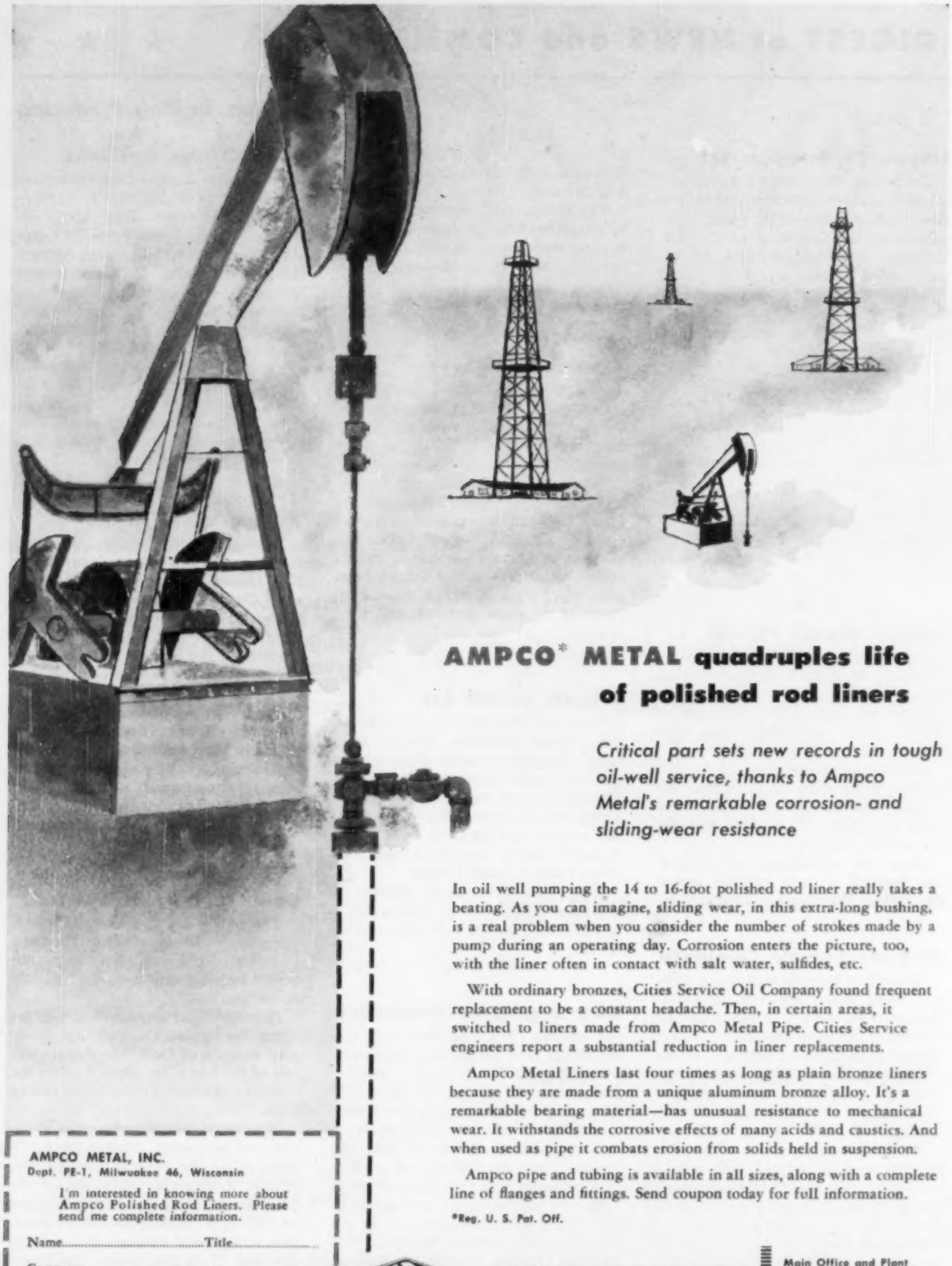
Dow Absorbs Brazos

The Brazos Oil and Gas Company, a wholly-owned subsidiary of The Dow Chemical Company, has been absorbed by the parent company, officials announce.

Newly-merged organization will become the Brazos Oil and Gas Company division of Dow. The merger was one of the first to be effected under the recently-revised Texas corporation code.

Headquarters will continue in Houston and personnel, headed by L. B. Swan as division general manager, will remain unchanged. Activities of the division will come under the direction of Dr. A. P. Beutel, Dow vice president and general manager of the Texas Division. Until the merger, Dr. Beutel served as president of Brazos Oil and Gas.

The company is presently operating in California, Michigan and Texas.



AMPCO* METAL quadruples life of polished rod liners

Critical part sets new records in tough oil-well service, thanks to Ampco Metal's remarkable corrosion- and sliding-wear resistance

In oil well pumping the 14 to 16-foot polished rod liner really takes a beating. As you can imagine, sliding wear, in this extra-long bushing, is a real problem when you consider the number of strokes made by a pump during an operating day. Corrosion enters the picture, too, with the liner often in contact with salt water, sulfides, etc.

With ordinary bronzes, Cities Service Oil Company found frequent replacement to be a constant headache. Then, in certain areas, it switched to liners made from Ampco Metal Pipe. Cities Service engineers report a substantial reduction in liner replacements.

Ampco Metal Liners last four times as long as plain bronze liners because they are made from a unique aluminum bronze alloy. It's a remarkable bearing material—has unusual resistance to mechanical wear. It withstands the corrosive effects of many acids and caustics. And when used as pipe it combats erosion from solids held in suspension.

Ampco pipe and tubing is available in all sizes, along with a complete line of flanges and fittings. Send coupon today for full information.

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Company.....

Company Address.....

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New Firm for Permian

Texas American Oil Corporation has been formed to explore, develop and operate oil and gas properties in the Midland, Texas, area. The company has acquired leases, overriding royalties, and other oil and gas interests in 11 West Texas Counties.

Associated in the new million-dollar concern are T. F. O'Dell, president of Mutual Broadcasting System, Nash Dowdle, independent operator, John J. Dowdle, vice president of Great Lakes Carbon Corporation, P. M. Kelliher, Chicago attorney, and others.

★ ★ ★

High Pressure Process

Atlantic Refining Company is now applying its new high pressure gas process to a second reservoir. It is the 10,400-ft sand at Neale field, Beauregard Parish, Louisiana. Gas injection will be under way about January 1. This process was first applied in the University Block 31 field, Crane County, West Texas, in 1952.

The sand zone at Neale is a small solution gas driven reservoir with initial reservoir pressure at 4300 psi and present reservoir pressure at 3700 psi. Gas will be injected at 5300 psi bottom hole pressure in order to repressure to initial conditions. Atlantic has determined that the Neale reservoir fluid is particularly susceptible to the high pressure gas process and feels that this process will lead to significant increase in reserves.

The high pressure gas process makes use of the fact that some reservoir oils at high pressure can be displaced by hydrocarbon gas under conditions of fluid miscibility. The process is generally applicable to undersaturated reservoirs at pressures in excess of 3000 psi.

★ ★ ★

Refuge Leasing Banned

National wildlife refuges in many areas along the Gulf Coast will not be available for leasing "under any conditions," Secretary of Interior Douglas McKay has announced in a series of new regulations.

The new changes dealing with oil and gas leasing on national refuges have been designed to "strengthen protection and preservation of rare and endangered species, remnant big game herds, and irreplaceable examples of unique plants for animal ecology — such as the Aransas (Texas) whooping crane wintering area."

"MOST ELABORATE EXECUTIVE SUITE of offices in the Southwest" belongs to the 600 employees of the General American Oil Company of Texas. The nine-story Meadows Building in Dallas, named for General American's chairman of the board, is the property of the employee's retirement plan. The company, with its subsidiary and associated firms, operate in 11 states, Canada, Spain and Italy.

Oil in Baja California

Oil discovery has been made in Baja, California, officials of Petroleos Mexicanos have announced. Data on the discovery has not been made public, although it's known that six wells have been drilled in a basin near Iray Purisima, north of La Paz, capital of Baja California.

This is the first official report on discovery of oil on the penisula, although exploration has been conducted for over 25 years.

The claimed discovery follows a statement made recently by Mexican spokesmen that much oil would be found in the Tiajuana area, just south of the U. S.-Mexican border.

★ ★ ★

AAPG Hunts Emblem

Official emblem designing contest launched last spring by the American Association of Petroleum Geologists has attracted entries from all over the world.

Hundreds of drawings have been submitted to the 20-man judging committee, headed by Merrill W. Haas, exploration manager for Carter Oil Company, Tulsa, Oklahoma.

The emblem, to be used as a medallian, for buttons, flags, AAPG literature and stationery, will be picked at the next annual meeting in Chicago on April 23-26. A first prize of $50 and a second prize of $25 will be awarded, and the contest is open to the general public.

Lease Revenues Rise

Louisiana received more than $100,000,000 in 1955 from state land revenue paid by the oil and gas industry. Most of the amount came from bonuses, rentals and royalties paid for exploration and development.

Last year $70,000,000 was paid to the State Mineral Board for these purposes.

December leasing included about 30 inland tracts on about 9000 acres, and two Delta area tracts, off Plaquemines Parish.

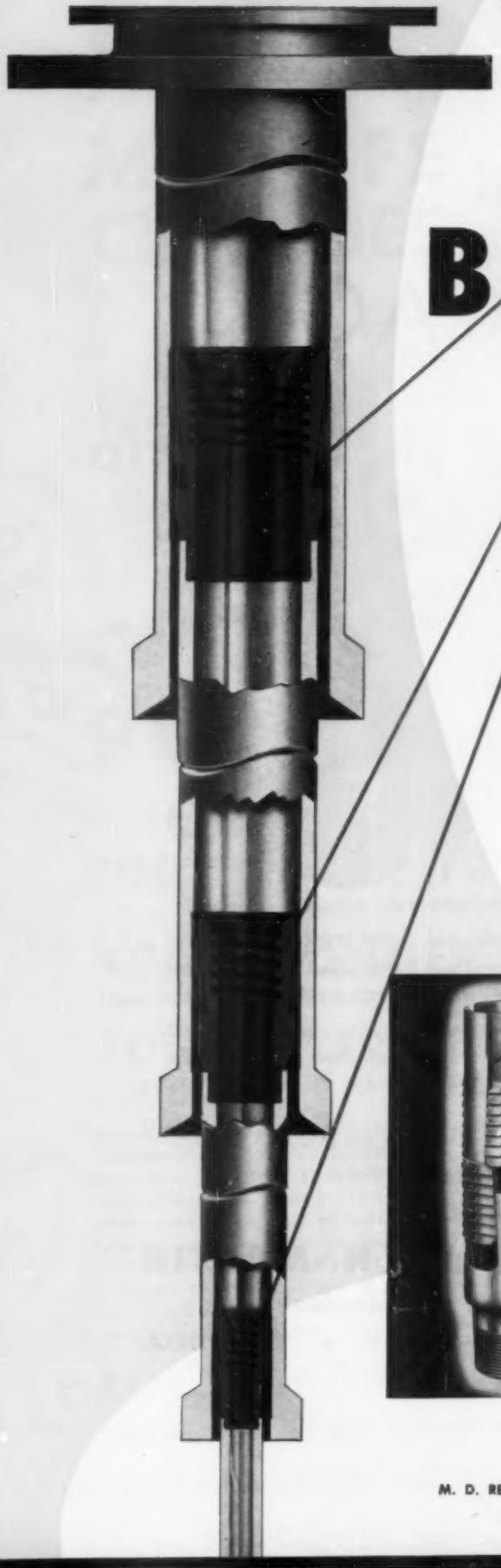
★ ★ ★

Cuban Holdings Increased

Siboney Development and Exploration Company has acquired 100 per cent of the outstanding capital stock of eight Cuban companies from Caribbean Petroleum Associates, Inc. Siboney exchanged 2½ million shares of its common stock plus $250,000 for the stock of the eight companies, who own claims for concession rights on approximately 5,000,000 acres in Cuba.

Its acreage is in Oriente Province at the eastern end of the island, in the central provinces, and in shallow offshore areas including the Gulf of Batabano which lies between Havana Province and the Isle of Pines. First exploratory well will be started in Camaguey Province near the south shore of Cuba soon.

Siboney was originally a joint venture of Crescent Corporation and Sterling Oil of Oklahoma, Inc.



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KEEP UP YOUR PRESENT DRILLING COMMITMENTS WITH LESS INVESTMENT PER WELL. USE A CASING HANGER

Here's the most profitable piece of equipment in the well drilling business today. What other single tool will effect savings up to 25% of well completion costs? Miles of costly pipe are saved with the Burns Casing Hanger because the overlap is eliminated.

You also assure a successful cement job which is the most critical operation in drilling and conditioning an oil well. The Burns Casing Hanger is an all purpose tool designed to:

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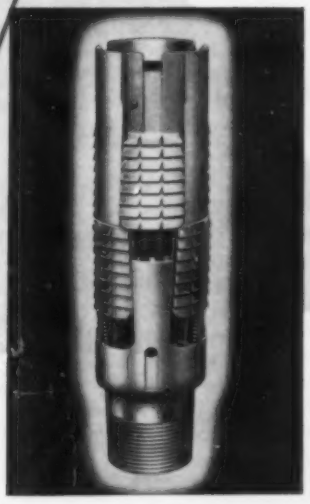
The success of the Burns Liner Hanger is built around the slip design. Instead of the conventional tapered cone used to force slips outward, the Burns patented construction provides specially broached single plane runners on which slips travel with a full 100% backup contact at all positions. No "two point" slip support and no cracked slips but instead a true 100% wedge—the Burns patent.

Thousands of Burns Casing Hangers are used today. Available in all popular sizes. Prices on request.



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When pencil, paper and manufacturing skill were fused in the development of the Martin Cage, one guiding thought was held constantly in mind. *Make a better cage — a cage which would stand the terrific punishment that caused ordinary cages to fail.*

The result, of course, was the Martin Cage. And today, after years of use by economy-minded producers, this one significant fact remains undisputable. *With Martin Cages, ball and seat life is often doubled . . .* So successful has been the Martin Cage that some manufacturers are attempting to follow in its footsteps. Naturally, only Martin can make a Martin Cage.

The secret of Martin Cage's long life is the oil proof rubber ball guides. The resilience, resistance to sand abrasion, non-magnetic character and electrical resistance of this rubber guide successfully combat cage problems. They are manufactured in

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Operate longer without adjustment or plate replacement

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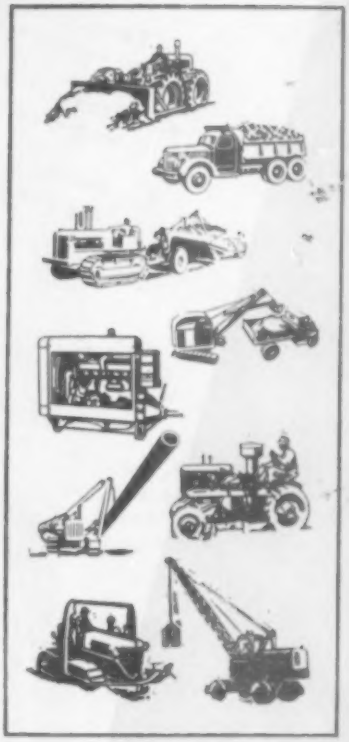
Avoid down-time caused by burned or warped plates



These NEW type ROCKFORD clutches have been developed and field tested by Rockford Engineers for heavy-duty clutch service. Because of their specialized characteristics, MORLIFE type ROCKFORD clutches are best suited for use in off-the-road machines such as tractors, trucks, tanks, cranes, shovels, bulldozers, earth movers, pipe layers, power units and other heavy duty equipment. For information how this NEW development will improve the operation and increase the on-the-job hours of your heavy-duty machines, write Department E.

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ROCKFORD Clutch Division BORG-WARNER

1303 Eighteenth Avenue, Rockford, Illinois, U.S.A.

INTEROFFICE MEMO

To: Products Approval Committee

From: Chief Engineer

An Engineer Talks About W-K-M Valves

Subject: Basis for recommending standardizing on W-K-M Valves

Here are the facts substantiating my verbal recommendation about these valves.

1. They have a positive seal on both the upstream and downstream side.
2. Their parallel expanding gate is expanded against the seats with great force by the stem screw, after the gates are in full closing position. The gate moves freely when valve is being opened or closed.
3. Their through-conduit is the same I.D. as the pipe so there is no turbulence to cause erosion.
4. Pressure Seal Bonnets eliminate flanges and studs, self-adjust to temperature changes, and seal tighter as pressure increases.
5. Double row thrust bearings on stem absorb thrust...make opening and closing easier.
6. Lubrication provided by filling body cavity with grease, also inhibits corrosion.
7. Easy field repair while on the line...the entire valve can be repaired without removal.
8. They're available in any size and pressure range we have ever needed, including the new 15,000 p.s.i. working pressure balanced stem valve.
9. They are available with all types of connections: screw ends; weld ends; flange ends; screw by flange ends; unequal flange ends; and special cross types.
10. W-K-M has been making valves for over 30 years, and others I've talked to about them give their unqualified approval on every count. Seems to me it would be to our advantage to standardize on W-K-M Valves.

W-K-M Valves

W-K-M MANUFACTURING COMPANY, INC.

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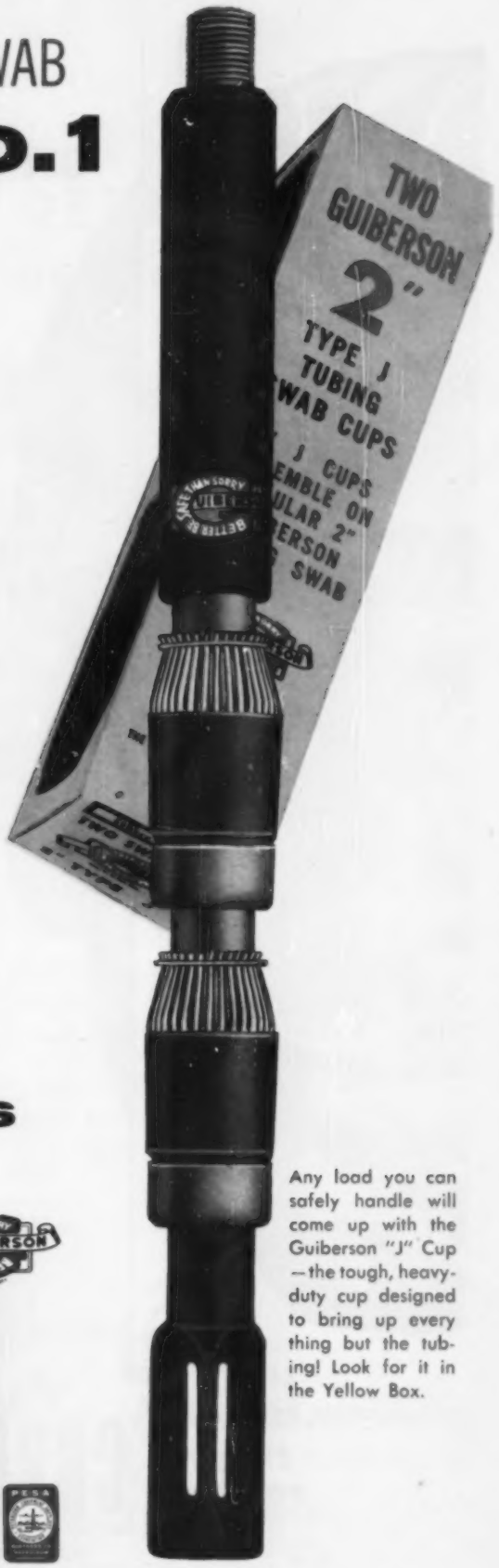

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EQUIPMENT

HOLE SIZE IS NO PROBLEM—the inherent cutting action of diamonds is not affected by bit size. You get the same greater core recovery and longer bit life whether your hole is large or ultra slim, and . . .

DIAMOND BITS ADD TO THE ADVANTAGES OF "SLIM HOLE"—because Christensen Diamond bits have no bearings or moving parts, there's no design problem to cope with in the smaller sizes—they drill a straighter hole because less proportionate weight is required for effective penetration. In many cases, when hole size is reduced, penetration rates increase because higher rotational speeds are possible. Also these bits can be used with all types of circulating fluids even in the smaller sizes.

BITS ACTUALLY COST LESS—since the cost of a diamond bit is determined by the amount of diamonds used, the smaller the bit the less it will cost.

See your nearest Christensen engineer for complete information on "Slim Hole" equipment. There are core bits—drilling bits—wire line and conventional core barrels—washover shoes—and reamers for any hole size.

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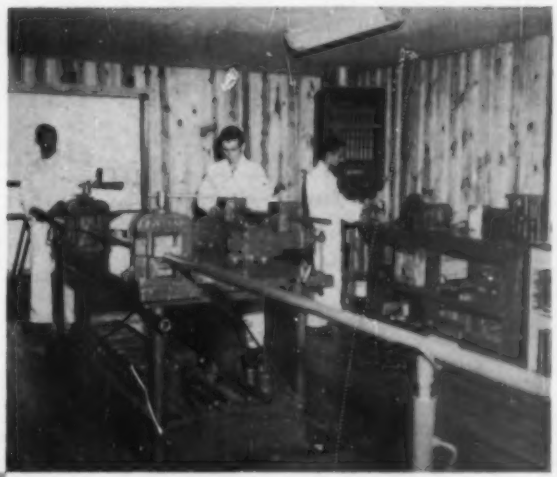

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Double Shut-In Pressure Readings Provide More Information — In Less Time — Than Other Methods

"WHAT IS THE main advantage of double shut-in pressure readings?" That's a question often asked by those who have not yet tried this newest method of drill stem testing.

Actually there are *four* main advantages of the double shut-in pressure method:

1. Maximum formation pressure build-up in shortest time.
2. Comparison of reservoir build-up pressures before and after test.
3. Two separate chances to obtain reservoir pressure.
4. The measuring of the true equilibrium pressure prior to producing the formation provides a virgin pressure measurement and more accurate data.

Perfected by Johnston Testers, this new technique requires only a simple rearrangement of the test tool assembly. By placing a disc valve above the main or hydraulic valve, a specified volume of air is trapped between these two valves. This volume of air is called the "air chamber."

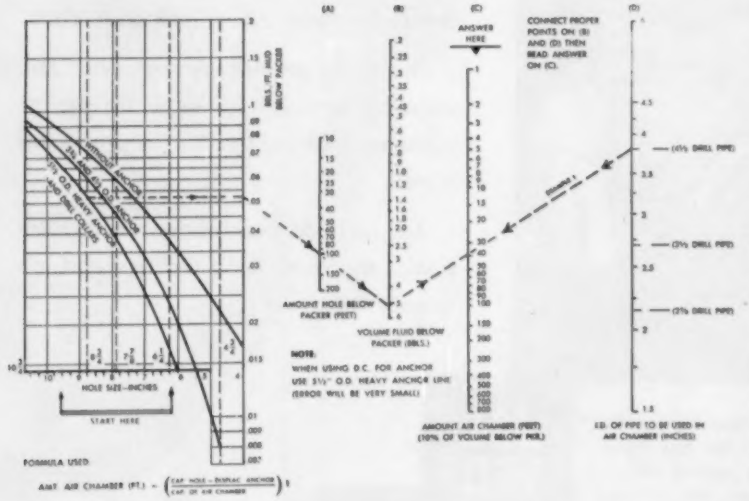
As the purpose of the air chamber is to relieve the mud pressure trapped below the packer, the secret of success of double shut-in testing is accurate use of this air chamber. Best results have been obtained when volume of the air chamber is about 10% of the volume of mud below the packer.

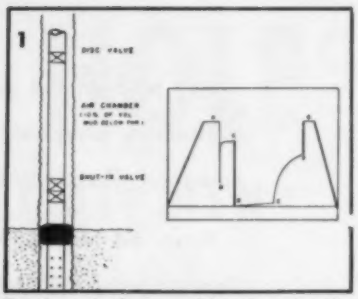
In the past, it has been common to calculate the air chamber to the nearest 30-foot pipe length. This lack of accuracy has often caused a failure to record the *maximum* initial shut-in pressure.

To overcome this problem, and to do away with complicated mathematics, Johnston has developed an "air chamber alignment chart." By simply drawing straight lines between known figures, the amount of air chamber needed can be calculated quickly and accurately.

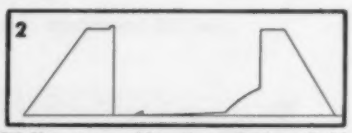
The chart below shows how simple it actually is to use this method.

Complete information on double shut-in testing is available from Johnston Testers, Houston, Texas. Write today for complete descriptive folder.

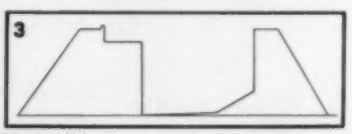

(A)
(B)
(C)
(D)
ANSWER HERE
CONNECT PROPER POINTS ON (B) AND (D) THEN READ ANSWER ON (C).
AMOUNT HOLE BELOW PACKER (FEET)
VOLUME FLUID BELOW PACKER (BBLS.)
AMOUNT AIR CHAMBER (FEET) (10% OF VOLUME BELOW PKR.)
HOLE SIZE—INCHES
START HERE
NOTE:
WHEN USING D.C. FOR ANCHOR USE 3½" O.D. HEAVY ANCHOR LINE (ERROR WILL BE VERY SMALL)
FORMULA USED



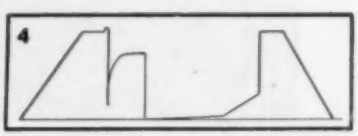
Testing tool assembly for double shut-in pressure readings which permits a limited fluid withdrawal. By placing the disc valve above the main or hydraulic valve so that a specified volume of air is trapped between these two valves.



Well not capable of producing fluid fast enough to fill up air chamber and cause pressure build-up.



Mud did not expand enough to get pressure draw-down below the formation pressure.



Mud expanded and pressure draw-down was below the formation pressure. Well was able to flow enough fluid to fill up air chamber and build-up shut-in pressure.

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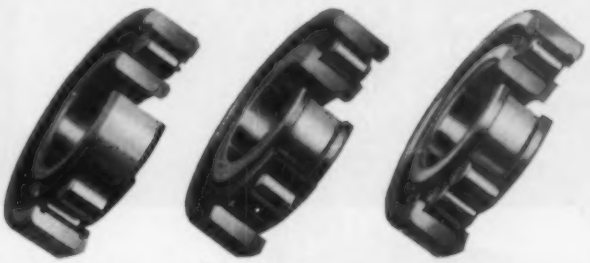
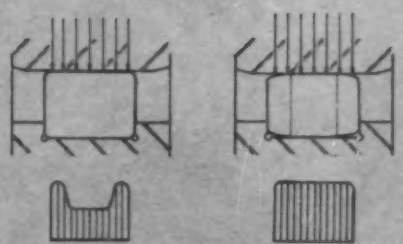


Stamped Steel Retainer with Guide Lips

Segmented Steel Retainer

Full Roller

Comparative Stress Patterns under Uniform Loads for Straight and Crowned Cylindrical Rollers



Stress pattern for a straight cylindrical roller under load. Note uneven end-loading.

Stress pattern for crowned roller under load. Crowning radius is exaggerated for clarity.

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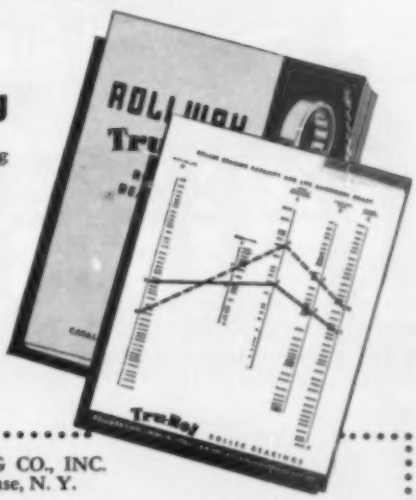

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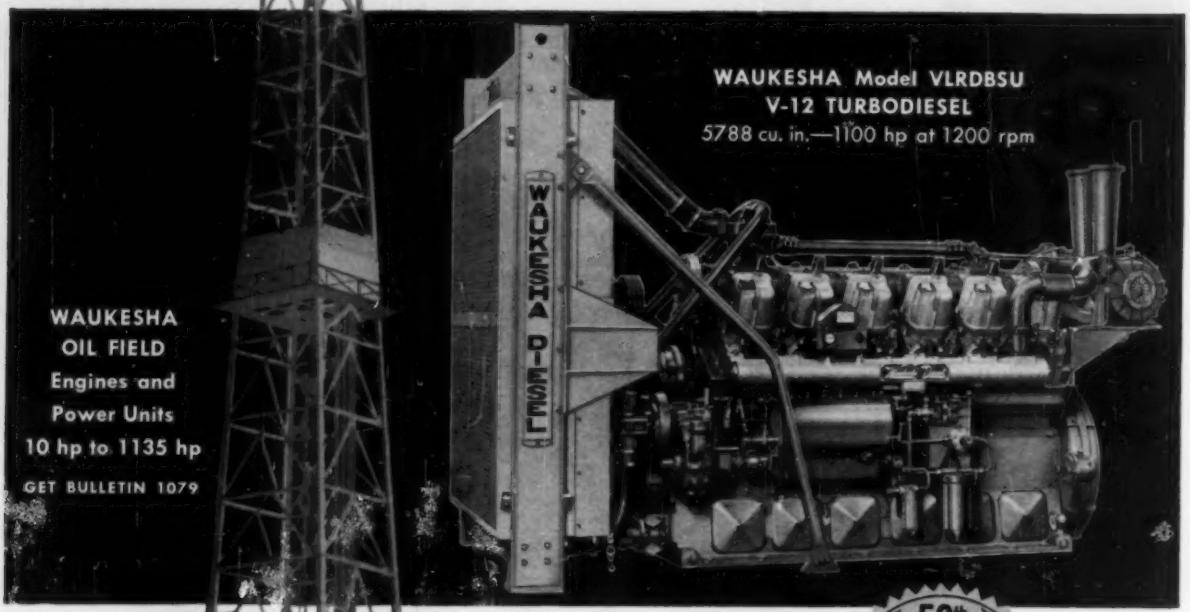

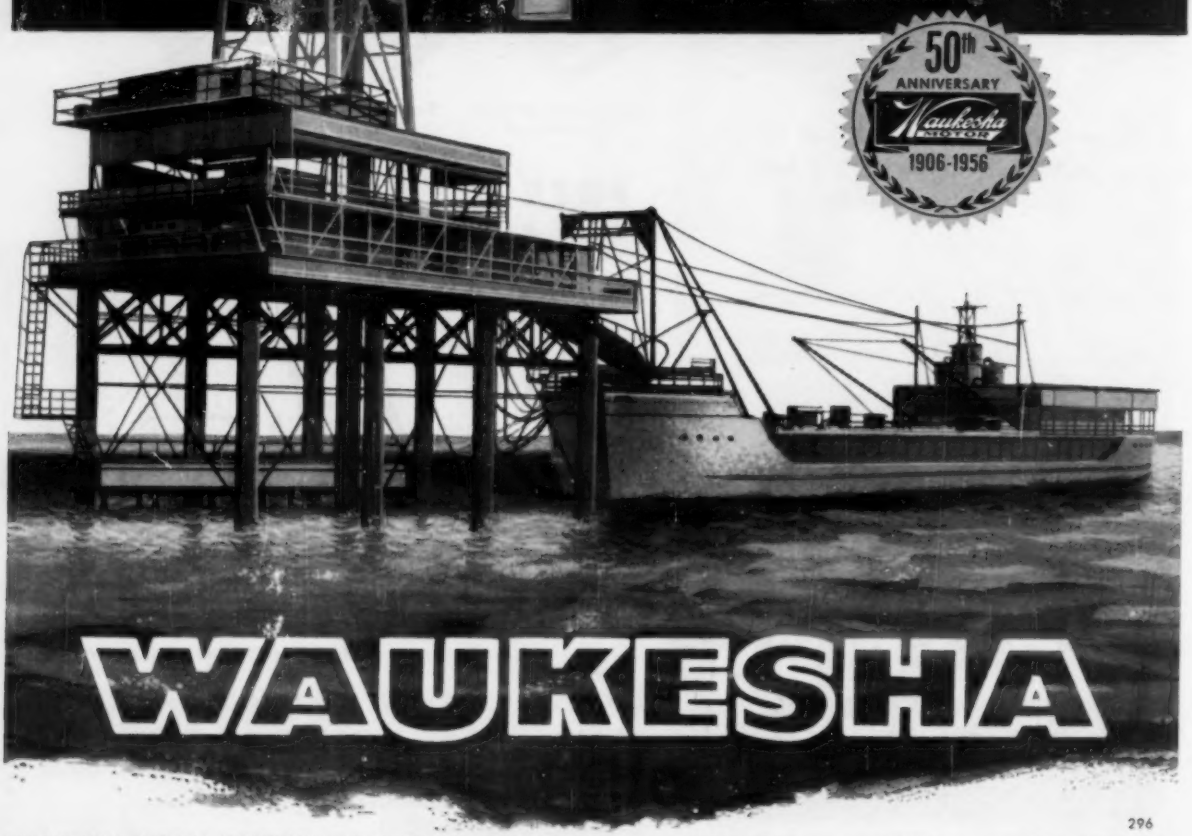

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Some Observations on

Drilling With Air

Field Experience and Investigations Shed More Light On Down-Hole Explosions

Earl R. Bruno
District Production Manager,
Ada Oil Company,
Midland, Texas

A considerable number of wells have been drilled successfully and economically by using air as the circulating medium. Interest has mounted in recent years in this new method, and field tests are continuing. Use of air involves special considerations not only in technique but in the use of equipment as well. Here are some observations in air drilling based on experience gained in drilling several wells by this new method and from extensive investigations into the subject of explosive hazards.

Volumes Needed. Volume of air necessary to drill and remove cuttings from the hole depends upon the size hole drilled and the size of drill pipe used. The key to air drilling lies in the velocity of air in the annulus between the drill pipe and wall of the hole. As long as this velocity is great enough to lift the cuttings, drilling can be accomplished regardless of the air pressure or depth of the well. Velocities of 2000 to 3000 lin ft per minute have been found to drill efficiently at depths thus far encountered. A minimum velocity figure is 2000 fpm, with 3000 fpm being the economical efficient velocity. For example, a 12¼-in. hole was drilled efficiently by using two 600-cfm and one 315-cfm, 100-psi air compressors with 4½-in. drill pipe, resulting in an annular velocity of 2140 fpm. With one 600-cfm and one 315-cfm air compressor to drill an 8¾-in. hole with 4½-in. drill pipe, the annual velocity is 2970 fpm. An annular velocity of 3550 fpm was attained when drilling a 4¾-in. hole with 2⅞-in. drill pipe and using one 315-cfm compressor. In all cases above, these wells were drilled efficiently.

Maximum discharge pressure of the air compressors used was 100 psi. To decrease back pressure on the air compressors while drilling the 12¼-in. hole with 1515 cfm, it was necessary to increase the port area of the rock bits by cutting the matrix out of the center of the bits. There was not sufficient port area in 12¼-in. rock bits with jet ports to allow the necessary volume to pass at 100 psi. Table 1 shows the volumetric requirements in cubic feet of free air per minute necessary to provide 3000 fpm velocity for various possible combinations of hole size and drill pipe size. This table was taken from Hughes Tool Company Engineering Bulletin No. 24.

Regarding Cutting Size. It is felt that cuttings are broken up into fine dust-like particles by the abrasive action of the walls of the hole on the drill pipe as the cuttings travel up the annulus. It is believed that the cuttings originally are normal in size when first drilled or cut by the bit. To date, the only wear noticed on the drill pipe has been on the tool joints that have not been hard faced. No excessive amount of wear has been noticed on hard faced tool joints. Considerable wear was found to exist on the bottom drill collars, where the cuttings are large and velocities are high.

Downhole Explosions. Considerable discussion has been given on downhole explosions resulting from drilling into a gas zone with air that produces a gas-air explosive mixture. It was found that under the air drilling pressures used in wells on which this experience is based, a gas-air mixture between 5 and 15 per cent would be considered an explosive mixture. A gas-air mixture of 9 to 10 per cent at this pressure being the most explosive.

Effect of Composition of Air-Gas Mixtures. One of the most complete studies made on combustible gas mixtures was that by Elting Henderson, as reported in a paper presented at the 1941 Annual Proceedings of the Pacific Coast Gas Association. The following discussion and data on gas-air explosive mixtures were taken from this report. To determine the effect of composition of gas-air mixtures, Henderson varied the per cent of gas in the gas-air mixture from 6½ to 12.6 per cent using a 337-ft length of pipe and igniting these mixtures in the pipe. Effect of this variation of composition on flame speed and pressure developed was measured. His results are shown in Fig. 1. Initial pressure was atmospheric and ignition was at the open end of the pipe, the other end being closed. The highest pressure of 32 psi was recorded for 10½ per cent of gas. Pressures of less than 1 psi were noted for 10½ per cent and above, and for 6.4 per cent and below.

Fig. 2, taken from Henderson's report, shows the relationship between per cent of gas in the mixture and maximum pressure developed for the case of turbulent flow. Gas in the mixture was varied from 6.5 to 12.8 per cent as it flowed through a 3000-ft section of pipe at 1000 fpm velocity at one atmosphere initial pressure. Ignition point was at the closed upstream end; the other end was opened. It was impossible to ignite the mixture at 12.8 per cent gas. Ignition of the 6.5 per cent mixture was obtained, but a pres-

EXCLUSIVE

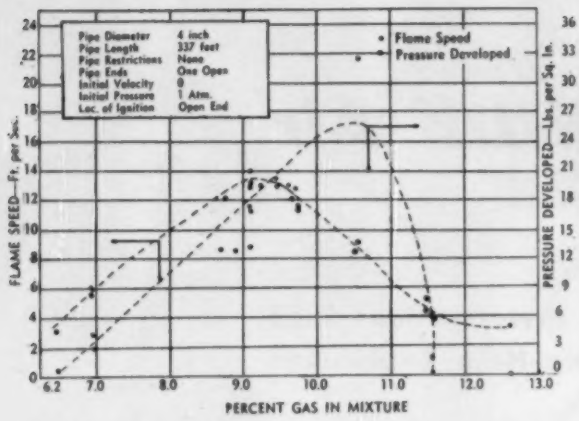

FIG. 1. Effect of composition of quiescent gas-air mixture on flame speed and pressure developed.

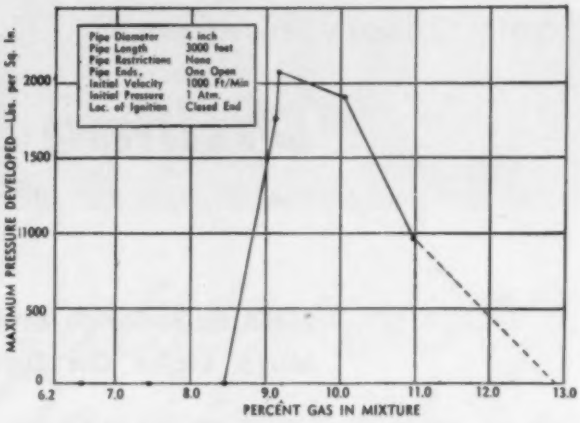
Pipe Diameter 4 inch
Pipe Length 3000 feet
Pipe Restrictions None
Pipe Ends, One Open
Initial Velocity 1000 Ft/Min
Initial Pressure 1 Atm.
Loc. of Ignition Closed End
MAXIMUM PRESSURE DEVELOPED—Lbs. per Sq. In.
PERCENT GAS IN MIXTURE

FIG. 2. Effect of composition of gas-air mixture on pressure developed for turbulent flow.

sure of only a few pounds per square inch was developed. A mixture of 9.2 per cent gave the highest pressure of 2130 psi.

Quoting from Henderson's report, "Location of the ignition point has an effect on the severity of the high-pressure waves produced. This effect is demonstrated in the results of experiments with gas-air mixtures at atmospheric pressure in turbulent flow in which the ignition point was located 0, 10, 25, 42 and 50 ft from the closed upstream end of the pipe, and at approximately 100-ft intervals thereafter. At only the 0 and 10-ft locations were high pressures developed. Detonation was not obtained when, at an initial pressure of 60 psi gauge, turbulent gas-air mixtures were ignited near the midpoint of the 337-ft pipe."

Effect of linear velocity of gas-air mixture on the maximum pressure developed is shown in Fig. 3, also taken from Henderson's report. He stated, "Under conditions indicated in Fig. 3, the linear velocity of the mixture through the pipe was varied from 0 to 1150 fpm in an attempt to ascertain the effect of velocity on the maximum pressure developed. With linear velocities of 130 fpm, there were no pressures that reached 50 psi. At 254 fmp and higher, maximum pressures at about 2300 psi were recorded. It appears that flows well into the turbulent range are necessary for the development of high-pressure waves. Tests also showed that when the pipe length was as much as 337 ft, it makes no difference if the end away from the ignition point was opened or closed."

Effect of Initial Pressure. "Under turbulent flow conditions" reports Henderson, "pressures developed were measured along the length of the pipe, varying the initial mixture pressure and keeping all other variables constant. Separate series of experiments were run for 337 ft and for 3000 ft of pipe to determine if variation of length had a noticeable effect on the pressure distribution. Curves representing the pressure developed at different positions

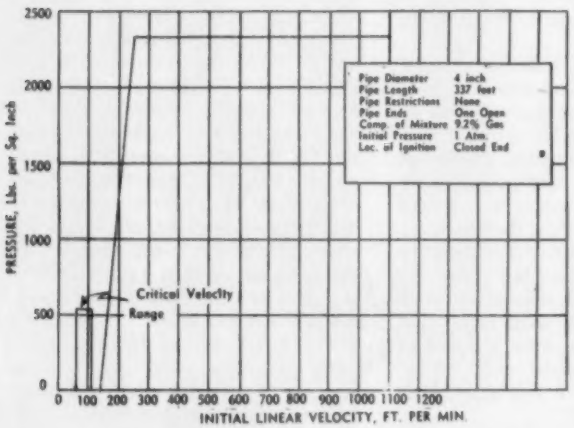
Pipe Diameter 4 inch
Pipe Length 337 feet
Pipe Restrictions None
Pipe Ends One Open
Comp. of Mixture 9.2% Gas
Initial Pressure 1 Atm.
Loc. of Ignition Closed End
Critical Velocity Range
PRESSURE, Lbs. per Sq. Inch
INITIAL LINEAR VELOCITY, FT. PER MIN.

FIG. 3. Effect of linear velocity of gas-air mixture on maximum pressure developed.

EFFECT OF LINEAR VELOCITY

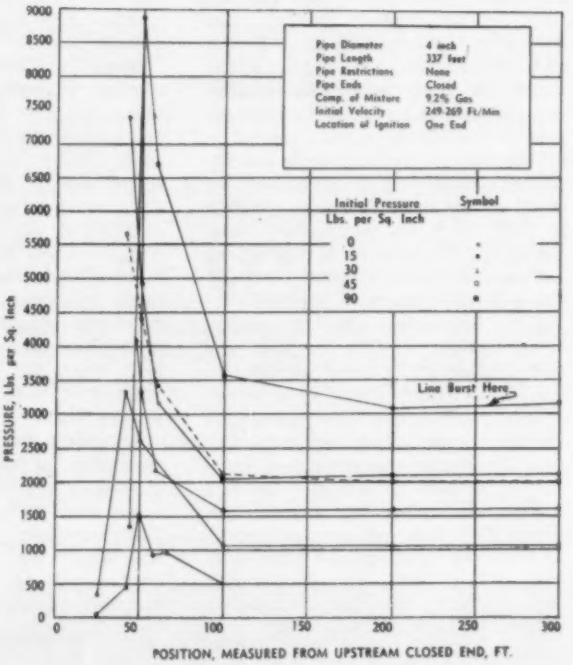

FIG. 4. Effect of initial pressure of gas-air mixture on pressure developed for turbulent flow in 337-ft tube.

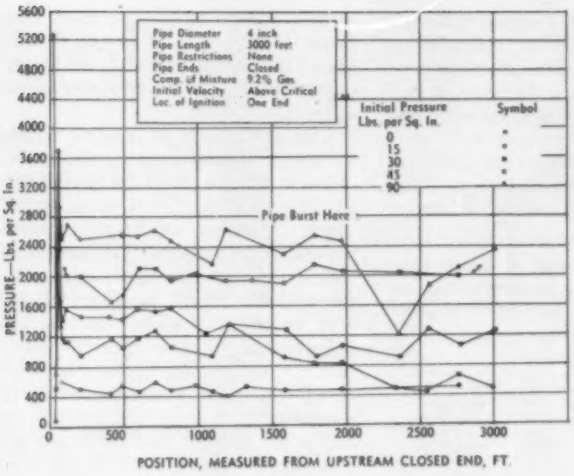

FIG. 5. Effect of initial pressure of gas-air mixture on pressure for turbulent flow in 3000-ft tube.

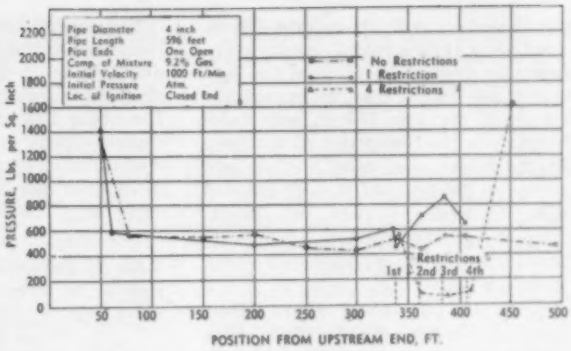

FIG. 6. Effect of 2-in. diameter restrictions on pressure developed.

along the pipe as a function of initial mixture pressures are shown in Fig. 4 and 5. These curves show that the pressure begins with a rather low value that continues for about 25 ft from the ignition point located at the upstream end of the pipe. It quickly increases to the peak pressure that occurs near the 50-ft mark in both the 337-ft and 3000-ft lengths. It then falls off almost as quickly to a value considerably higher than the initial value, and either continues at a constant value down the remainder of the pipe or gradually falls off in an irregular manner. Even though the stresses in the pipe at the peak pressure are probably beyond the ultimate yield strength of the pipe, duration of the unstable detonation is so brief that there is insufficient time for much strain to occur due to the inertia of the pipe mass."

Effect of Restrictions. Henderson further reports, "The effect of restrictions on the duration of the explosion (reciprocal of flame speed) was not noticed. The only difference noted was the occurrence of sharp audible reports, the number of which corresponded to the number of restrictions. Restrictions, consisting of orfice plates having 2-in. diameter holes, were placed in successive experiments at 338, 361, 385 and 409 ft from the ignition location along the 596-ft of pipe. Excessively high pressures were not noted. The effect of restrictions placed downstream from the ignition point and the point of maximum pressure intensity was to initiate another pressure peak at approximately 50 ft beyond the restriction location, as illustrated in Fig. 6, where pressure developed along the pipe is plotted."

"In two experiments performed under identical conditions using 3000 ft of line having a restriction (¾-in. offset orifice) located at 337 ft from

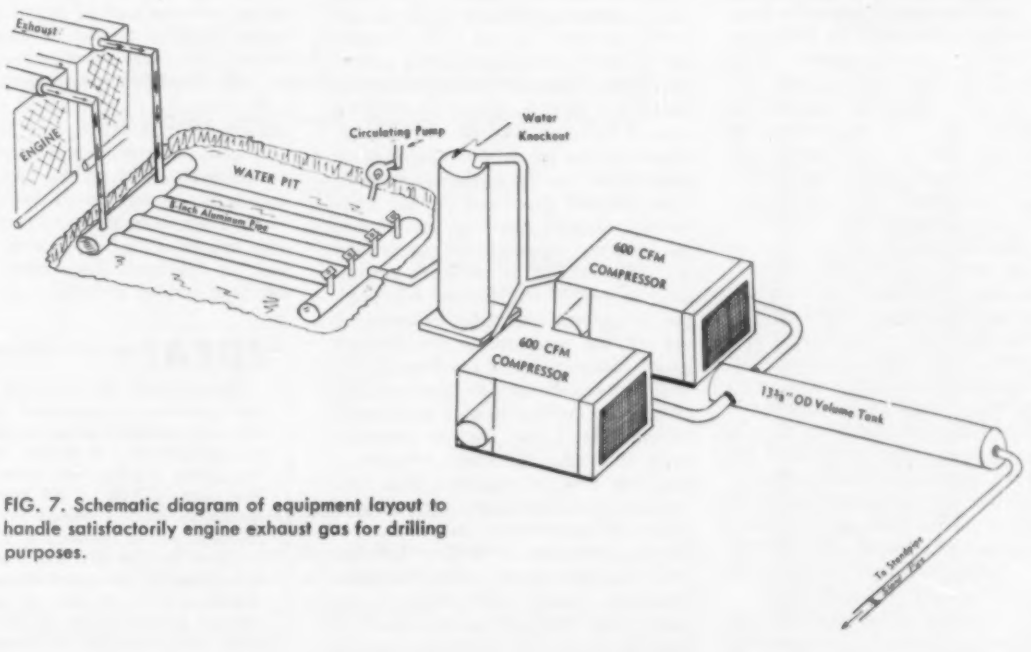

FIG. 7. Schematic diagram of equipment layout to handle satisfactorily engine exhaust gas for drilling purposes.

the upstream end, detonation developed when the turbulent air-gas mixture was ignited 10 ft from the upstream end. In one case, detonation occurred in the first 337 ft, with mild burning in the remainder of the line. In the other case, mild burning occurred in the first 337 ft, with detonation developing beyond this point. Thus, a restriction can either block, intensify or initiate a detonation wave in gas-air mixtures."

Data and discussion above taken from Henderson's paper indicate that with a perfect gas-air mixture of 9 to 10 per cent gas in air and with a spark hot enough to set off the gas-air mixture, it is possible that a high-pressure explosion can occur while drilling with air. When drilling, the air-gas mixture in the annulus would be heavily dust-laden. Since the flame speed is dependent upon the heat transfer from burning gas layers to unburned layers ahead of the flame and since the pressure developed is directly proportional to flame speed, it is believed that the resulting magnitude of pressure developed from an explosion would be greatly reduced due to the dust-laden gas-air mixture slowing down the flame speed. One well on which these experiences are based was drilled with a 7 to 10 per cent gas-air mixture for a period of several weeks without an explosion occurring.

TABLE 1. Volumetric requirements (Q) in cubic feet of free air per minute necessary to provide 3000 fmp velocity for various possible combinations of hole size and drill pipe size. Data taken from Hughes Tool Company Engineering Bulletin No. 24, revised April 19, 1954.

Hole diam. D3 (inch)	Pipe OD D2 (inch)	Q Cubic feet per minute
4¾	2⅜	234
	3½	169
5⅜	2⅜	382
	3½	318
6¼	3½	439
	4½ (4 x 4 sq.)	308
6¾	3½	545
	4½ (4 x 4 sq.)	414
	3½	690
7⅞	4½ (4 x 4 sq.)	559
	5½	395
	3½	814
7⅞	4½ (4 x 4 sq.)	683
	5½	520
8⅛	4½ (4 x 4 sq.)	851
	5½	687
	6⅝	464
8¾	4½ (4 x 4 sq.)	921
	5½	758
	6⅝	535
	7	451
9⅝	5½	921
	6⅝	798
	7	714
9⅞	5½	1101
	6⅝	877
	7	794
10⅝	5½	1352
	6⅝	1129
	7	1045
	8⅝	930
11	5½	1485
	6⅝	1262
	7	1178
	8⅝	763
12¼	5½	1990
	6⅝	1737
	7	1654
	8⅝	1238

Temperature and Pressure Effects. Temperature and pressure both tend to widen the limits of inflammability, the effect being greater on the upper limit. The upper limit of inflammability increases rapidly from about 12½ per cent methane at atmospheric pressure to about 47 per cent at 6000 psi. The upper limit of inflammability for a methane-air mixture at 60 to 80 psi (about the pressure existing during normal air-drilling operations) would be about 15 per cent. Temperature increases the flame speed of the gas, and therefore, would increase the explosive force of an air-gas mixture.

Table 2. Estimated cost of butane-propane to be added to drilling air to go above limit of inflammability of butane-air mixture.

Total quantity of drilling air used	Total quantity of butane used	Estimated cost butane (7½¢ gal)
2,000,000 SCF/D	6450 Gal/D	$484.00/D
1,500,000 SCF/D	4840 Gal/D	$363.00/D
1,000,000 SCF/D	3226 Gal/D	$242.00/D
750,000 SCF/D	2420 Gal/D	$182.00/D
500,000 SCF/D	1613 Gal/D	$121.00/D

Table 3. Estimated cost of N2 to suppress inflammability of natural gas-air mixture.

Total quantity of Drilling air used	Total quantity N2	Estimated cost of N2
2,000,000 SCF/D	480,000 CF/D	$1920.00/D
1,500,000 SCF/D	360,000 CF/D	$1440.00/D
1,000,000 SCF/D	240,000 CF/D	$ 960.00/D
750,000 SCF/D	180,000 CF/D	$ 720.00/D
500,000 SCF/D	120,000 CF/D	$ 480.00/D

Effect of Diluent Gases on Limits. Calculations and actual experimental data show that a methane-air-CO_2 mixture containing as much as 24 per cent CO_2 is impossible to explode. Approximately the same percentage of nitrogen will prevent an explosion in a methane-air-N_2 mixture. To add CO_2 or nitrogen to the systems in quantities to provide a non-explosixe mixture would be prohibitive in cost. Therefore, to get a non-explosive mixture, it was decided on one job to cool the exhaust gases from the rig engines, compress these exhaust gases and use the compressed exhaust gases as the circulating medium in place of compressed air. This hookup is shown schematically in Fig. 7. This process was used, but it was not successful in knocking out all the moisture in the exhaust gases. Moisture would condense in the drill pipe and dampen the dust cuttings, causing the cuttings to stick to the walls of the hole. Later, another company used this same process, wherein a scrubber was incorporated with conventional heat exchanger equipment to lower the temperature and remove objectional moisture. ("Drilling With Engine Exhaust Gases," **The Petroleum Engineer,** August, 1955, p. B-46.) Exhaust gases from gas engines should be used in this process since their oxygen content is so much lower than the oxygen content in exhaust gases from diesel engines. Use of engine exhaust gases for extended periods is not recommended because of the corrosive nature of the gas.

The addition of propane or butane to the air stream to bring the air-butane-gas mixture above the upper limits of inflammability was considered. Under conditions of 50 psi pressure, the amount of propane or butane necessary to get above the upper limit of inflammability would be about 10 per cent of the air-butane mixture. The daily cost of butane-propane necessary to get various quantities of butane-air mixture above the upper limit of inflammability is shown in Table 2, using seven and one-half cents per gallon as a cost basis. Table 2 shows the cost of adding nitrogen to the system. It might be possible to drill with a closed system and knock out cuttings from the returns and re-circulate the non-explosive mixture, thereby affecting some savings in either case.

Expected Results of Downhole Explosion. With an initial pressure of 50 psi, the maximum pressure in the annular space to be expected during operations, a maximum explosive force could be expected of approximately 2100 psi on the surface if a 9.2 per cent gas-air mixture existed over the entire depth of the hole. Momentarily, approximately 50 to 100 ft from the ignition point, a maximum pressure could be expected in the neighborhood of 3700 to 6000 psi due to the shock waves or detonation waves. Because of the dust-laden air-gas mixture, it is believed that the flame speed would be slowed down to such an extent that the explosive force would be negligible. Because of actual experience of drilling with explosive gas-air mixtures, it is felt that the probability of such an explosion ever occurring is slight. With intelligent supervision and strict safety measures enforced on the part of the drilling personnel and all those whose work brings them to the drill site, a gas zone can be drilled safely with air. In fact, to date there have been a considerable number of wells so drilled. ★

IDEA!

Cities Service Oil Company each year publishes a loose-leaf calendar with the names of employees on the leaf with their birthdate. At the top of the 5½ by 7-in. sheet is a line reading, "This is the birthday anniversary of," followed by a list of those whose birthday it is.

Cities Service men say that this is enjoyed by the entire company. Everyone is pretty sure to get a number of greetings on his birthday from fellow workers he knows.

Motor-switched capacitors such as the one shown circled have brought about considerable savings in the Panhandle and South Plains areas of Texas.

CAPACITORS PAY OFF In Electrical Beam Pumping

Proper application increases power factor, reduces voltage losses and improves motor starting torque

Roger K. Owen
Southwestern Public Service Co.

EDITOR'S NOTE: *This article is based on a paper entitled "Capacitors for Beam Pumping" by the author and presented at the American Institute of Electrical Engineers Petroleum Technical Conference held at Houston, Texas, September 12-14, 1955.*

ADEQUATE data seem to be available for the design of electric systems for oil well beam pumping and also for including capacitors in the design[1,2,3] of lease distribution systems. Purpose here is to publish data measured on operating leases as to the actual results of using motor-switched capacitors on leases that are typical of the Panhandle and South Plains areas of Texas. Information presented here is primarily for the oil producer who is interested in capacitors for one reason only . . . economics. How much money can be saved by using motor-switched capacitors?

First, it is necessary to review the heart of the problem — the reactive current demanded by the peculiar cylic load of the beam pumper. Fig. 1 shows an oscillogram of the current demanded by a 10-hp electric motor with and without a capacitor connected. Note that it is the light load current that is most reduced by the capacitor since this light load current is essentially and purely inductive.

Economics of Capacitors. The economics of capacitors essentially are involved in three major factors: (1) Reduced I^2R losses (system losses in kwhr); (2) improved operating conditions (voltage stability, better starting torque, less maintenance), and (3) savings in transformer and line capacity (more kva available). These three factors can be evaluated in terms of dollars and cents; the data can be measured, and they represent actual money saved on the leases studied.

There is not yet enough data available to define very well the effect of motor-switched capacitors on maintenance costs. Of course, there should be no theoretical effect at all, but in practice, a great many voltage conditions are bad enough that proper size heater strips or fuses cannot be used for obvious reasons. Also, there seems to be some voltage surge protection by capacitors. One company installed capacitors, and the percentage of its motors that had to be removed for repair per year changed from about 30 per cent to about 3 per cent. It was the belief by this company that most of the improvement was due to fewer thunderstorms, but some of the improvement almost certainly was due to better operating conditions of voltage. Repair incidence for adjacent leases for other companies remained around 10 per cent for these years. The figure for lowered costs due to capacitors has been conservatively set at 3 per cent for this study in order to recognize the factor as one to be considered.

Money Saved by Use of Capacitors. Five leases in the Panhandle and South Plains areas of Texas were studied, and the results are tabulated in Table 1. To

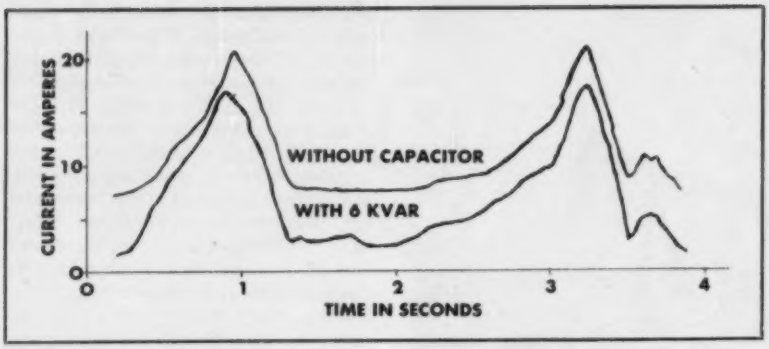

FIG. 1. Oscillogram of the current demand of a 10-hp motor installed on a beamed pump well. Note that the light-load current is reduced the greatest by the application of a capacitor.

Table 1

Lease	1 Per cent voltage increase	2 Per cent kwhr decreased	3 Per cent bank capacity released	4 No. wells and size in hp	5 Bank size kva	6 Cost capacitors dollars	7 Dollars saved for less kwhr/yr.	Bank capacity saved value dollars	9 Maintenance cost saved 3% per year	10 Total saving 1st year dollars	Per cent no. 7 of no. 6
A.	7.5	9.3	56	9–7.5	45	337.00	130.00	425.00	30.00	585.00	39
B.	4.5	3.5	45	7–7.5	27	70.00	63.00	204.00	24.00	291.00	90
C.	11	14	84	13–7.5	45	550.00	325.00	730.00	44.00	1099.00	59
D.	6	4	43	9–10	75	450.00	120.00	544.00	41.00	705.00	27
E.	6.6	10.4	53	2–10 10–7.5	75	462.00	374.00	680.00	43.00	1097.00	81

clarify the column headings, the following explanation of the table is presented:

Column 1 — Per cent voltage increase at the well most distant from the station after capacitors were installed.

Column 2 — Per cent kwhr decrease on the lease when capacitors were added. The figure includes improvement in motor efficiency, line I^2R losses, and in most cases, station efficiency.

Column 3 — Per cent transformer bank capacity release, in kva. Many banks were overloaded with capacitors.

Column 4 — Number and size of pumping wells on the lease. Virtually all wells were equipped with high-torque, normal-slip motors.

Column 5 — Installed bank capacity, in kva.

Column 6 — Cost of installed capacitors, at $12.50 per kvar. Lease B had only five of seven motors equipped with capacitors.

Column 7 — Annual dollar saving on kwhr purchased to pump the lease. Base cost used was 1.3 cents per kwhr.

Column 8 — Actual cost available in bank capacity. Practically all operators can utilize these extra kva, even on existing leases, by changing banks to fit lease demand or by removing one transformer and operating on open-delta system. Base cost used was $17.00 per kva.

Column 9 — Money saved in annual maintenance costs due to better operating conditions. Rewind cost was entered at $15.00 per horsepower and 3 per cent less repair per year was applied on the motors in use.

Column 10 — Total dollars saved from the three columns 7, 8 and 9.

Column 11 — Column 7 compared to Column 6. Annual pay out on I^2R losses only.

Savings are Apparent. Power factors in this area range from 35 to 50 per cent. Because these values are lower than many operators had believed them to be, it would pay to take another look at the advantages of using capacitors on existing leases. I^2R losses alone justify the installation of capacitors on many leases.

Other advantages not evaluated here include better starting torque, and perhaps considerable voltage surge protection. The only caution in using capacitors lies in educating operators to allow the capacitor to discharge before touching it if the capacitor is connected so as not to short them out by the motor copper circuit. It is believed that they should be connected so as to be switched with the motor, but not to effect the motor current through the heaters.

As to sizing, an adequate rule of thumb is to select a capacitor whose current rating is not more than the magnetizing current of the motor. The largest size capacitor to meet this requirement is the size to install.

An easy way to check the lease power factor is to have a representative of the electric utility company provide access to a test block of the meter. The power factor can be checked by clocking the meter disc first with one potential coil disconnected, then with the other disconnected. If the disc stops with the slow element potential disconnected, the power factor is 50 per cent. If it goes backward, the power factor is less than 50 per cent.

It would pay the operator to check the power factor and determine what motor-switched capacitors would take care of each lease. Capacitors should be incorporated in the installation of every new lease, and undoubtedly would pay on most leases already electrified.

References

1. "Power Distribution Systems for Oil Field Pumping Service." Bloomquist and Poore, General Electric Company.
2. "Application of Capacitors in Oil Field Production," Helms and Horrigan, 1948.
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SCC Builds New Offices, Lab

Construction of a new $800,000 facility to house the general offices and laboratories of Seismograph Service Corporation has been announced by G. H. Westby, president.

The new plant will consist of two buildings to be located on 20 acres of land southeast of Tulsa. A contract for the work has been awarded Cross Construction Company. The buildings are scheduled for completion in November, 1956, in time for SSC's twenty-fifth anniversary.

This will be the new home for the exploration firm which has done geophysical work in 40 countries, and is now working in 20 countries.

The main building will be a two-story structure, Lorac and other electronic and development laboratories. This building will be equipped with modern facilities for manufacturing, testing and assembly operations. The second building will be used for assembling and servicing the company's vehicular equipment.

Present Tulsa facilities include seven different locations in the downtown area. These separate activities will be integrated in the new buildings.

The second structure will bring the floor space of the plant to 70,000 square feet. This smaller building will be used for assembly and servicing of its vehicular field equipment.

The two buildings will be of modern design and constructed of steel reinforced concrete, faced with brick. The grounds will be landscaped for year-round attractiveness.

Technical Tips . . .

On Selecting Fracturing Fluids

Factors To Consider When Specifying a Fluid To Fit Individual Well Conditions

J. K. Henderson
Dowell Inc.
Chief Field Engineer

SINCE the introduction of hydraulic fracturing as a method of stimulating production from oil and gas wells, many different types of fracturing fluids have been developed. These include crude and refined oils, hydrocarbon and aqueous gels, and various types of oil emulsions made with brine or acid. Even though the sand used as the propping agent may be responsible for sustaining the production increases obtained, the fracturing fluid still governs the placement of that sand.

Many factors enter into choosing the proper fracturing fluid for any specific treatment. The type of formation (limestone, dolomite, sandstone, conglomerate, etc.) understandably plays a large part in this choice. Other factors, such as type of porosity, degree of cementation and naturally occurring fracture system, if any, all must be taken into consideration. There is no universal fracturing fluid for best results. In some areas, a high fluid-loss media gives best results; in another, a low fluid-loss material is preferred. Similarly, acid fracturing fluids may be highly successful in some oil fields, while another area obtains optimum stimulation using an oil-base fluid.

Early fracturing jobs were performed using No. 6 fuel oil, a sticky, viscous oil having a high asphalt content. This material proved satisfactory for low-volume jobs, but with the trend toward larger treatments, it was noticed, particularly in low bottom-hole pressure wells, that a long clean-up time was required. Also, some operators experienced difficulty in reselling the oil to the pipe line companies due to its high asphalt content.

A search was made to find a more desirable oil for fracturing operations. Many oil wells were available, but the question of economy was of primary importance. For instance, a good grade motor oil would make an excellent fracturing fluid, but the cost would be prohibitive.

The first oil chosen was green in color, had an extremely high viscosity, was obtainable at a fairly low cost and was acceptable to pipe line operators. High viscosity was considered vital since it was believed that this characteristic was necessary to keep sand in suspension properly. Another difficulty arose, however. When attempts were made to increase the injection rates during treatment, high friction losses were encountered with this viscous oil. As a result, prohibitively high surface pressures were required to attain the necessary formation fracturing pressures at the bottom of the well.

Finally, a compromise oil was chosen. It had sufficient viscosity to support the sand satisfactorily, yet was low enough to permit the use of higher injection rates.

Fracturing Fluid Research

Research study of fracturing oils did not stop here, however. Extensive tests were conducted to determine just which components of the oil were responsible for its characteristic properties, i.e., viscosity, sand-carrying ability, fluid loss, etc.

Hendrickson, Foster and Rosene reported that these properties were a function of the three major constituents of the oil, namely paraffin waxes, asphaltic material and the base oil.

Viscosity, for example, is primarily a function of the base oil and its constituents. Asphaltic materials are present in the form of micelles, thickening the oil and decreasing the rate of fall of sand through the oil. Paraffins, however, due to their limited solubility, are present partly in solution and partly in the form of microscopic crystals. Thus, they function primarily as bulking agents rather than thickeners. Temperature is a controlling factor in this case, influencing the solubility of the paraffin crystals. Above the melting point of these waxes, of course, they are completely in solution and no longer influence the viscosity or sand-supporting characteristics of the oil. It is of interest to note that the presence of asphalt in the oil limits the crystal size of the undissolved paraffin waxes present, thus altering the sand-falling rate of the oil.

In actual use, the presence of large amounts of paraffin wax or asphaltic material is undesirable. These dispersed materials may be precipitated upon dilution with formation fluid, resulting in a partial plugging of the formation with resultant lowering of production. For this reason, it is desirable to employ oils that do not contain appreciable amounts of waxes or asphaltic materials but whose physical characteristics are a function of the base oil itself.

Influencing Factors

Essentially, there are three factors that govern the success of a fracturing treatment — the injection rate, the propping agent and the fracturing fluid.

The question of what injection rate should be employed is receiving considerable attention from oil operators. The demand is for increasingly higher injection rates in order to obtain deeper fracture penetration and improved decline curves. This has, in turn, necessitated the development of new heavy-duty pumping equipment, capable of supplying the necessary horsepower to attain these high injection rates at high pressures. Heavy diesel engines, originally designed for ordnance use, are being utilized in connection with high-capacity pumps. By pressurizing the suction of these pumps, it has been possible to increase their efficiency as well as to smooth the flow through the discharge line, cutting down on vibration at the well head.

The second factor, that of propping agents, is important in obtaining maximum extension of fracture with minimum danger of screen-out. Generally speaking, graded 20 to 40 mesh, round-grained sand is being used. In some cases, where a dense formation is en-

countered or the initial fracture will not accept this size sand, a spearhead of smaller 40 to 60 mesh sand is used. In most cases, this is readily followed by the 20 to 40 mesh sand, without a screen-out. In some cases, where a softer formation will permit it, the initial 20 to 40 mesh sand has been followed by a larger 10 to 20 mesh sand. This should provide a more permeable pathway to the well bore when the well is produced. This patented procedure for following one size of sand with another[2] has proven beneficial in a number of well treatments.

The third factor, that of the fracturing fluid, is believed by many to be the most important of all. In evaluating a fracturing fluid, sand-carrying ability, fluid loss and viscosity should all be taken into consideration. Each of these characteristics is influential on the type of fracture that is created, and none can be completely ignored.

The Author

J. K. Henderson as chief field engineer for Dowell, Inc., supervises and coordinates the practical field adaptation of research laboratory developments. He has been closely associated with fracturing operations and aided in the improvement of treating methods. A graduate of the University of Oklahoma, he joined Dowell in 1947 at Bossier City, Louisiana, as service engineer. He later became district engineer at Wichita Falls, Texas, and was appointed chief field engineer at the Tulsa, Oklahoma, general office in 1953.

Sand-Carrying Ability

The sand-carrying ability of a fracturing fluid is important from two different standpoints. First, it must carry the sand down the well bore to the face of the formation being fractured. This becomes important only if, for some unexpected reason, injection must be temporarily halted due to equipment breakdown or other difficulty. Then, if the shut-down is not of too long a duration, the sand will remain in suspension and a screen-out avoided. A more important need for good sand-carrying ability, however, is after the fluid is in the formation. The longer the sand can remain in suspension, the deeper the fracture penetration that can be expected. Most operators feel that this extensive penetration of the sand will result in an improved decline curve.

A typical case history may be cited in support of this theory. In fracturing

Kermac Launches Sixth Offshore Rig

Rig 45, newest addition to Kerr-McGee Oil Industries, Inc. Gulf Coast drilling fleet, has left the shipyards and is beginning to make hole on its first well, in the Ship Shoal area off Terrebonne Parish, Louisiana.

Rig 45 was designed by the marine engineering staff of Kermac, and was built by the Ingalls Shipbuilding Corporation of Pascagoula, Mississippi. A self-contained drilling barge, Rig 45 is officially designated as an "offshore mobile platform drilling unit."

Two similar Kermac rigs are operating in the Gulf — Rig 40 and Rig 44. Kerr-McGee also has three tender-platform type drilling units operating offshore. Operation of these rigs requires the services of a fleet of other vessels, tugboats, work boats, crew boats and cargo barges.

First assignment for Rig 45 was a contract to drill a well for the Texas Company, the OCS -0313 No. 1 in the Ship Shoal area.

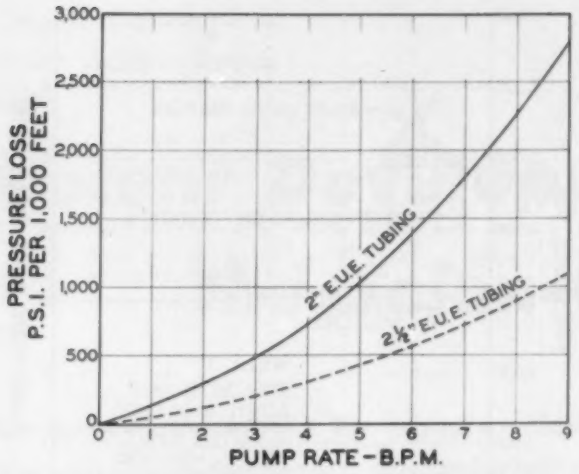
Rig 45 is designed to operate in water up to 35 ft in depth. A submersible drilling device, it is submerged by pumping water into the hull which supports the rig and other equipment. The rig is stabilized during submersion by two pontoons riding on guide rails at either side. Once the hull is on bottom, the pontoons are submerged and imbedded in the mud by the force of hydraulic rams.

Several innovations are incorporated in the operating mechanism of the pontoons. A feature unique to Rig 45 and her sister vessel, Rig 44, is the C-shaped shoe which is the connecting link to the guide rail. A simple design, the shoe can be removed or installed easily, permitting rapid detachment of the pontoons.

Attachment frame design includes a floating hinge that insures a four-point contact against the guide rails, and a horizontal slide permitting the barge to incline a maximum of six degrees with respect to the pontoons.

Superstructure of Rig 45 is 175 ft long by 54 ft wide. The hull measures 142 ft, with a depth of 13½ ft. Pontoons are 146 ft by 11 ft. The Texas deck is 55 ft above the base line of the hull.

Kerr-McGee also has let a contract for construction of another floating tender for use in offshore operations.



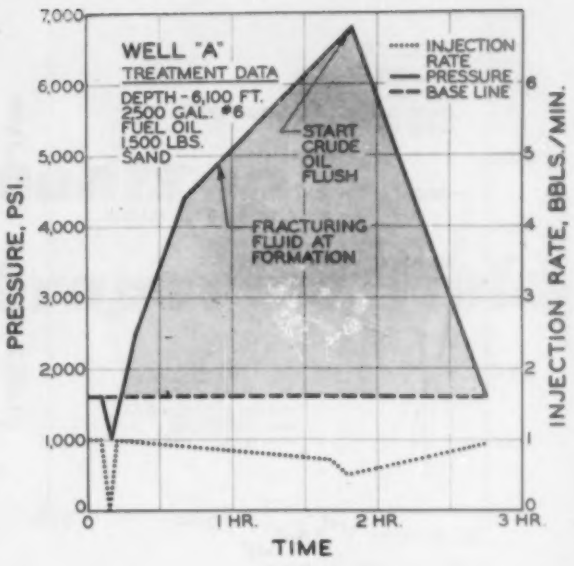


FIG. 1. Calculated friction losses when pumping oil through tubing. FIG. 2. *Right,* lost horsepower when fracturing with a viscous fluid is shown as the shaded area under the curve. Dashed line shows formation breakdown pressure and is used as a base for calculating power losses.

a well in North Texas, an attempt was made to set up conditions that would produce a vertical formation fracture. A low fluid-loss material was placed in the hole and a 20 ft mono-directional glass gun lowered into the well opposite the face of the formation where the fracture was desired. It was hoped that the jet perforating would help initiate a vertical fracture, which would in turn be opened up during the sand-injection stage of the treatment.

The well was pressured up, the gun fired, and the fracturing treatment followed. Afterwards, a spinner survey was run that showed that all of the fluid had entered a 6-in. section opposite the point where the two 10-ft sections of the mono-directional gun had been fastened together. It is safe to assume that a horizontal fracture was created.

The initial production of this well was not any better than that of surrounding wells that had been fractured conveniently. Later production data, however, revealed that the decline curve was much better than those of the offset wells. It is believed that the low-fluid loss material acted somewhat like a liner, restricting the loss of the fracturing material to the point of the original rupture. As a result, all of the fracturing materials entered at this one spot, resulting in a deeper fracture than was obtained in any of the surrounding wells.

Importance of Fluid Loss

The fluid loss of the fracturing media also influences the kind of fracture that is obtained. If the carrying fluid escapes rapidly into the matrix, not only at the face of the well bore but through the faces of the fracture, the sand will not be carried very deeply into the formation before becoming immobilized.

The importance of this factor was brought out in a recent survey of two large oil field areas. These two areas were geologically similar, yet while outstanding production increases were maintained in the one area, a high initial production was followed by a rapid decline, in the other.

In an attempt to determine the reason for these dissimilar results, a tabulation was made of 302 service reports, one-half from each area. The results are shown in Table 1.

TABLE 1. Summary of fracturing operations in two major areas.

	Area #1	Area #2
Average Size of Treatment (gallons)	3200	3500
Sand Ratio (pounds/gallon)	1.8	2.3
Average Injection Rate (BPM)	4.1	4.7
Average Overflush (barrels)	36	27
Type Fracturing Fluid		
a. Oil-water emulsion	49.3%	7.8%
b. Lease oil	46.8%	6.3%
c. Semi-refined oil	3.9%	85.9%
Treatments Employing Mud-Acid Spearhead	17%	28%

It may be seen that there were but minor differences in the total gallonages, sand ratios or injection rates. The principal difference is in the type fracturing fluid used. In Area No. 1, characterized by rapid declines, the principal fluids used were lease oil (having high fluid-loss properties) and a lease oil-water emulsion (having fluid-loss properties resembling that of the lease oil from which it was prepared). In comparison, in Area No. 2, a semi-refined oil fracturing fluid was used, with which a high degree of fluid-loss control can be obtained. It is believed that this factor produced greater penetration of fractures, resulting in sustained production increases.

Effect of Viscosity

The viscosity of the fracturing fluid is an important factor that should not be overlooked. With the demand for higher injection rates, viscosity has been sacrificed, in order to avoid the high friction losses experienced in pumping the more viscous oil. There are times, however, when viscosity can mean the difference between a successful job and a screen-out.

A few years ago, an old well in the KMA area of North Texas resisted efforts to fracture it at the injection rates then in use. This well was finally fractured successfully by using a spearhead consisting of 1000 gal of extremely viscous oil. The increased viscosity created sufficient pressure differential to fracture the formation and permit injection of the sand. With modern high-capacity pumping equipment, this can now be accomplished by the use of high injection rates.

The problem of friction losses in pumping viscous-oil fracturing fluids is one that should not be dismissed as inevitable. Merely because high horsepower is available with modern fracturing equipment, does not mean that this power should be wasted in forcing the oil down the tubing rather than being utilized at the face of the pay. Even with the reduced viscosity of present-day fracturing oils, there is considerable power loss, as is shown in Fig. 1.

New Fracturing Fluid Developed

In an attempt to conserve some of

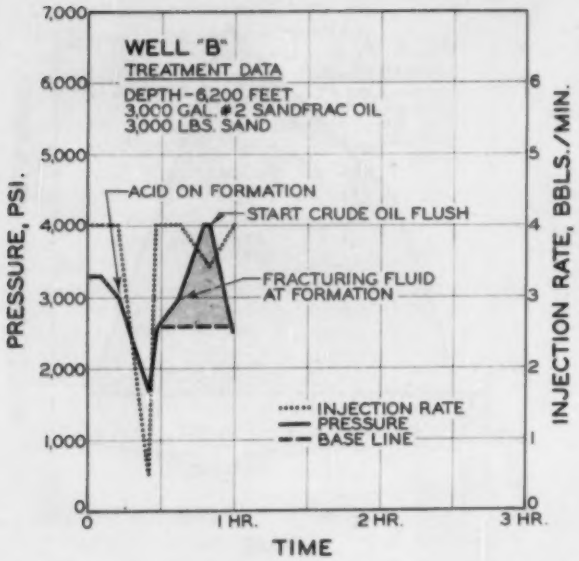


FIG. 3. As pressure goes up, power losses increase as demonstrated in this case. Acid on the formation ahead of the treatment caused the sharp dip in pressure drop of the base line.

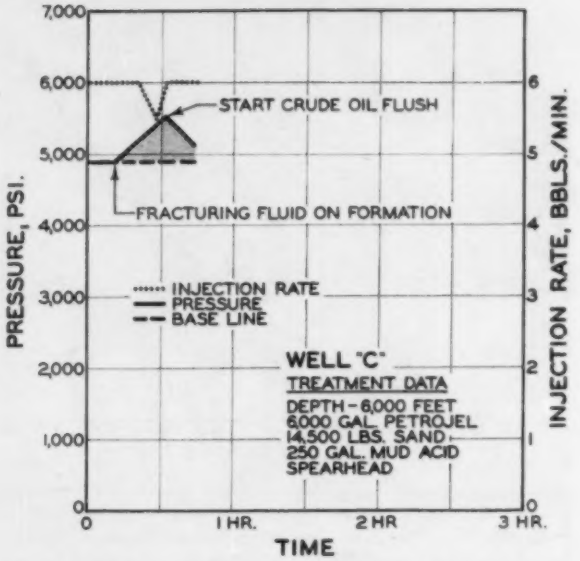


FIG. 4. Power loss is low in this case as shown by the shaded area under the pressure curve. A modified crude oil tailored for the job as well as a spearhead of acid.

this wasted power, a new fracturing fluid has been developed. This new fluid consists of lease crude that has been modified by the inclusion of addition agents. The resultant fluid has very nearly the same sand-carrying ability and fluid-loss characteristics as refined-fracturing oil. However, the friction losses, such as are experienced with other fracturing fluids, are greatly reduced. This may be seen by comparison of a number of fracturing jobs. In Fig. 2, the shaded area represents the amount of horsepower that is lost to friction alone when a viscous fracturing oil is used. Assuming that the lowest surface pressure (including friction loss) required to inject fluid into the formation is that at which the breakdown oil (lease oil) enters, this pressure is taken as the base line. The increase resulting when the fracturing fluid is pumped into the tubing will be due to two things—(1) friction and (2) the force necessary to inject the sand into the formation. The shaded area, representing these two factors, shows that approximately 65 per cent of the available power is being wasted in overcoming this loss. As a result, only 35 per cent of the purchased horsepower is being utilized at the face of the pay. The dashed line shows the injection rates during the treatment.

Fig. 3 shows a similar condition. As the pressure goes up, the power loss increases and the injection rate drops. Also of interest in this graph is the 700-lb drop in our base line, due to the effect of a mud-dissolving acid spearhead.

Fig. 4 shows the results that can be expected using the newly developed modified crude oil. Although there is still a small shaded area denoting power loss and a temporary decline in injection rate, the reduced friction losses permitted the use of much higher injection rates than were employed in the previous examples. As a matter of comparison, in the particular area where this job was performed, pressures of around 6200 psi were encountered at a 4 bpm injection rate, in similar treatments using conventional fracturing oil.

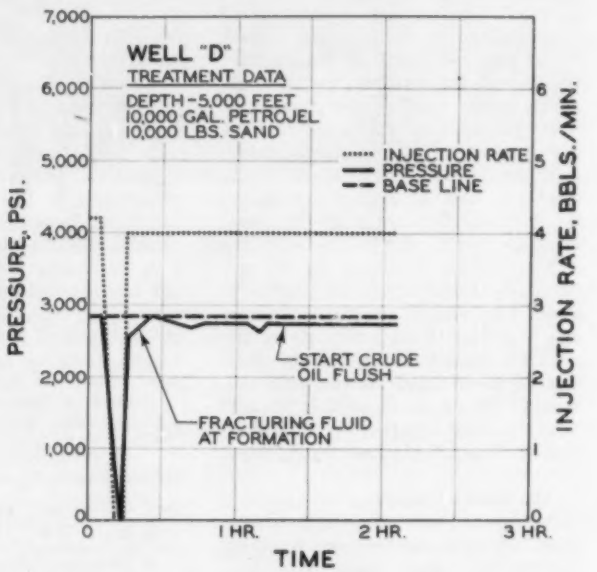


FIG. 5. The ideal fracturing condition. No power loss was experienced, and full advantage of the expended horsepower can be utilized at the face of the pay.

Fig. 5 shows the ideal condition. In this case, there was no power loss, with but 0.2 bpm reduction in injection rate, from that established with the lease oil. In a treatment such as this, full advantage of the expended horsepower can be utilized at the face of the pay. Another method of reducing friction losses is by doing down-the-casing treatments. There is no question but that whenever conditions allow (namely, low fracturing pressures and adequate casing), it is best to perform the job down the casing.

References

1. *"Investigations of Various Refined Oils for Formation Fracturing,"* Hendrickson, A. R., Foster, G. L., and Sosene, R. B., paper 477-G, presented at annual AIME meeting, Chicago, Illinois, February 12-17, 1955.
2. U. S. Patent No. 2,354,570.

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One of California's Most Active Areas . . .

Recent Developments in the Tejon-Grapevine Field

Geology complicated by complex fault patterns and numerous unconformities

John P. Lavery, Jr.
Reserve Oil and Gas Company
San Francisco, California

ONE of the most active areas in California during the past 18 months has been the Tejon-Grapevine field located in the extreme southeasterly portion of the San Joaquin Valley north of the Tehachapi Mountains and west of the Sierra Nevada Mountains. (See Fig. 1).

The mountainous areas consist of Jurassic basement rock with a border of Pleistocene to Eocene sediments exposed between base and valley alluvium. The forces that uplifted these mountain ranges, nearly at right angles to each other, developed complex fault patterns and numerous unconformities.

The Tejon-Grapevine field is divided into three distinct areas of production: (1) The Western Area, (2) the Central Area and (3) the Eastern Area. Practically all current production in the Western and Eastern areas is from Transition Zone sands. The Central Area now has six major producing zones: Transition, Santa Margarita, Pulv., Valv., Olcese and JV sands.

During the past 18 months, 59 wells were drilled in the Central Area for a total of 376,986 ft. Fifty-five of these wells were completed, 4 were abandoned and 1 is currently drilling. Of the producers, 2 were completed as new zone discoveries and one as a new pool discovery. New zones were discovered by deeper exploration when the original intended zones of completion were found to be non-productive. Development of the recent discoveries increased oil production from 1285 bbl per day from 56 wells in May, 1954, to 8360 bbl per day from 111 wells in October, 1955.

Fig. 2 shows the distribution of production and the number of wells in each zone. There are 36 Transition and Santa Margarita wells, 20 Pulv. Zone wells, 10 Valv. Zone wells, 22 Olcese wells, 1 Freeman Zone well, and 23 JV Sand wells.

The Upper Miocene Transition Zone sand ranges from 2600 to 2800 ft in depth, with productive intervals from 50 to 120 ft. The sand is fine to coarse grained and pebbly with a green clayey matrix. Permeabilities vary from 0 to 1200 md. Gravity of the oil is 16 to 18 deg API. The structure is a gentle fold plunging slightly to the west. Permeability governs the trap in some por-

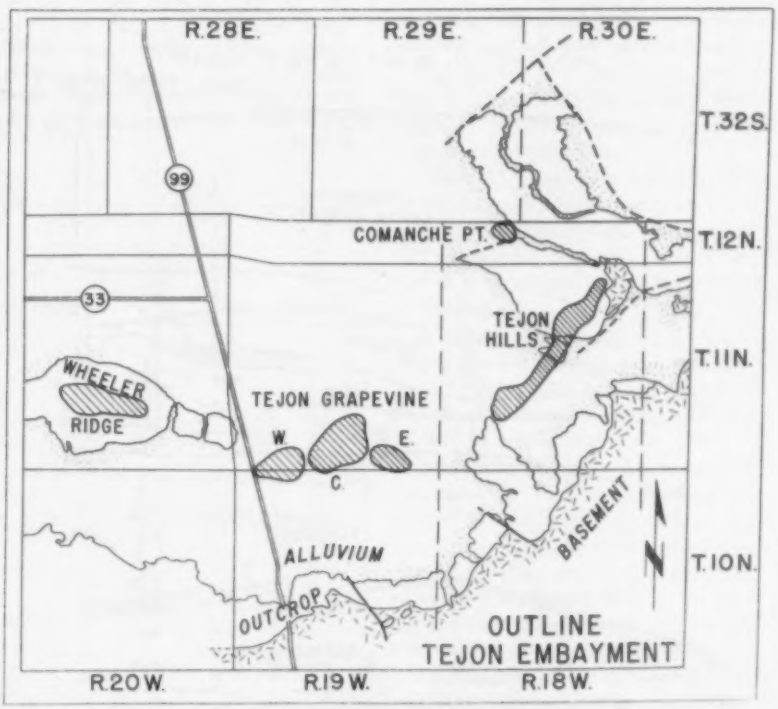

FIG. 1. **THE TEJON-GRAPEVINE FIELD** is located in the San Joaquin Valley north of the Tehachapi and west of the Sierra Nevada Mountains.

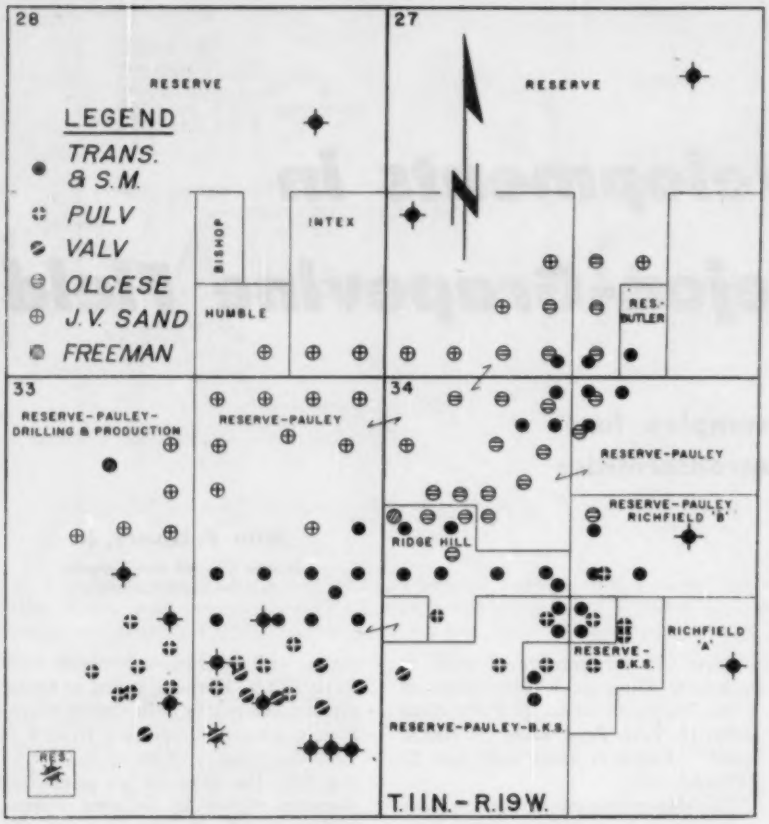

FIG. 2. **DISTRIBUTION OF PRODUCTION** and number of wells in each zone for the Central Area of the Tejon-Grapevine field.

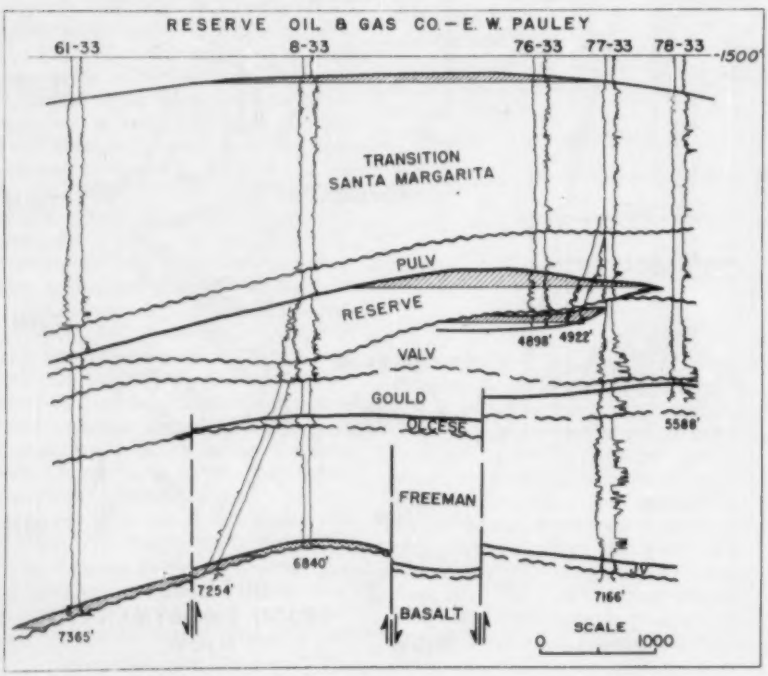

FIG. 3. **COMPLEX STRUCTURES** in the Tejon-Grapevine field are demonstrated in this crossection showing both faulting and unconformities.

tions of the area especially to the east. No gas cap is found in the main sand, but upper stringers apparently contain gas over the entire productive area.

A new Transition pool was discovered in December, 1954, in Reserve-E. W. Pauley Well No. 41A-34. Nine wells now produce 18-gravity oil from a depth of 2800 ft. This pool is apparently not connected to other Transition pools and the trap appears to be one of permeability.

Santa Margarita wells range in depth from 2700 to 2900 ft, with a productive interval of 60 to 150 ft. This sand, yielding 18-gravity oil, is medium grained and gray in contrast to the coarse green Transition. The trap is partly stratigraphic, with gentle folding with no gas cap.

The Pulv. Zone, Lower Mohnian, ranges from 3000 to 4600 ft and consists of shale and sand members, the most productive of which is the Reserve Sand. This sand, the first productive in the area, is bluish to brownish gray, biotitic, fine grained and well sorted with a somewhat clayey matrix. Overlying the sand is a shale body with a characteristic Pseudo-Saucesian faunule. Thickest portion of the sand occurs on the axis of a narrow anticline that plunges to the west. The section thins on the north flank and the sand shales out on the south flank.

The Valv. Zone has one productive sand about 80 ft thick at a depth of 4700 ft. First production from this sand was obtained in January, 1952. This Luisian sand is light gray, fine to medium grained, well sorted, clean and yields 33-gravity oil. Initial productivity indices ranged from 0.5 to 1.5 bbl per day per psi. An active water drive as well as an expanding gas cap provides the reservoir energy. The structure is an east-west fold with the sand shaling out on the south flank.

The Olcese pool was discovered in May, 1954, in Reserve-E. W. Pauley Well No. 42-34. The Olcese is a basal Relizian sand and conglomerate. The gas cap consists of thinly interbedded sands and shales approximately 150 ft thick. The oil reservoir consists chiefly of conglomerate with a medium grained, well sorted, crisp, clean oil sand matrix and varies from 40 to 170 ft thick at an average depth of 5650 ft. Permeabilities vary from 0 to 2000 md, gravity of the oil is 28 to 30 deg API and initial productivity indices varied from 0.3 to 2.5 bbl per day per psi. An expanding gas cap as well as an active water drive on the north flank provides the reservoir energy. The Olcese structure is a NE-SW trending anticline that is faulted on the south flank. A rapid facies change is exhibited by the Olcese conglomerate

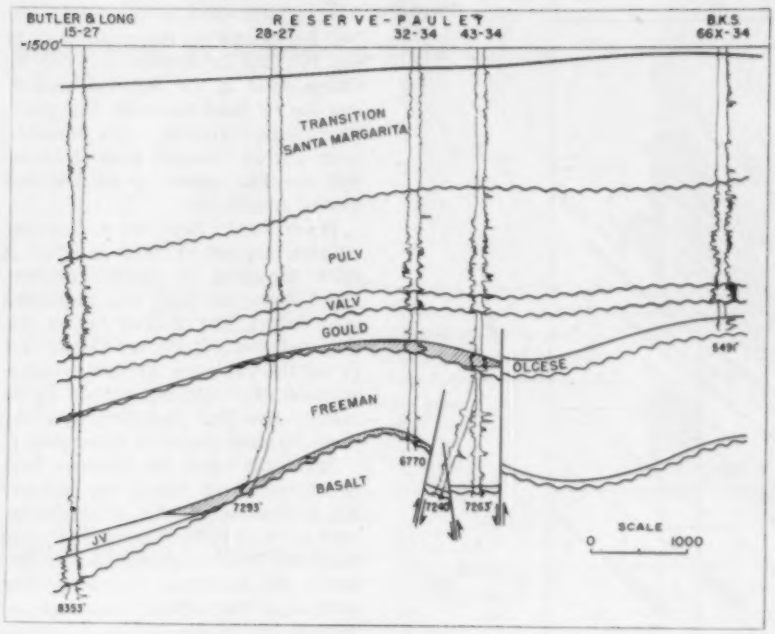

FIG. 4. **GEOLOGICAL CROSSECTION** showing faulting in the Olcese zone and in the JV sand.

being thickest on the NE nose, thinning to thin sands on the north flank, shaling out on the crest and becoming sandier again to the west.

The JV Sand was discovered in December, 1954, in Well No. JV 33-33, drilled jointly by Drilling and Production Company, Reserve Oil and Gas Company and E. W. Pauley. This Saucesian sand overlies basalt throughout the Tejon-Grapevine field. It is medium grained, well sorted, firm, and clean, from 45 to 100 ft thick at depths of 6600 to 7400 ft, with a gas cap of 15 to 20 ft covering an area in excess of 100 acres. Permeabilities range from 3.5 to 5000 md, gravity of the oil is 35 to 39 deg API and initial productivity indices ranged from 0.3 to 24.7 bbl per day per psi. The structure is a NE-SW trending anticline. Production is limited on the south by a pre-Olcese thrust fault. Productive limits to the west have not as yet been established.

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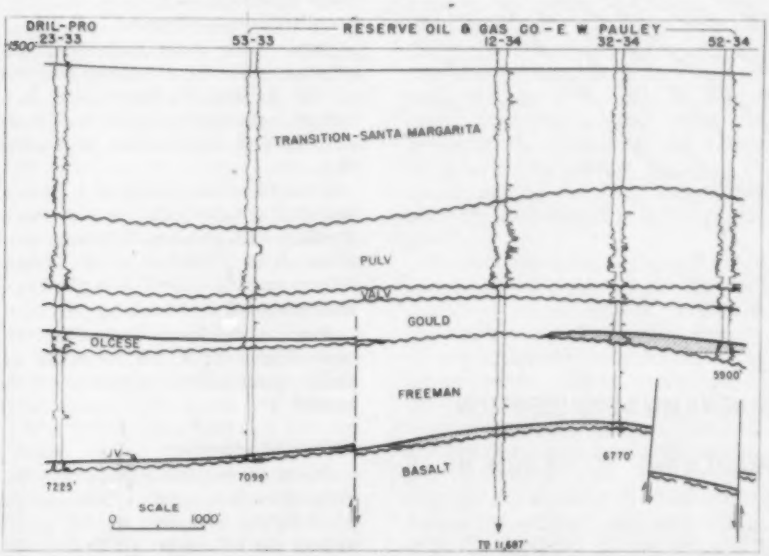

FIG. 5. **SLIGHT FAULTING** in the JV sand is indicated here, with an unconformity shown in the Olcese zone.

Packer Manual Published by Baker

One of the most all-inclusive manuals on one piece of oil field equipment has been published by Baker Oil Tools, Inc. The company has issued an attractive, 72-page catalog on the retainer production packer. Actually, the publication is a handbook encompassing many considerations in the application of the retainer production packer.

The retainer production packer, as developed by Baker, is one of the few changes in packer principle in several years—the first successful direct deviation from the hook-wall and anchor type removable packers. The new piece of literature was published to fill a vacuum of information on the new equipment.

The book is divided into six main sections. In the first division, the advantages, operation and variations of the packer are described. Second main category of the manual pertains to packer accessories, useful in certain applications, although not essential. A section on setting tools and setting tool accessories is given. Fourth main section concerns specifications and ordering instructions. Ten pages are allotted to operating instructions and procedures. In the last division 14 different applications are described. These include single zone, dual zone uses as well as testing, squeeze tool, secondary recovery and offshore installations.

The catalog first explains the functions and use of the packer in several pages of schematic and pictorial, as well as written accounts.

About 15 pages have been devoted to the use and selection of packer accessories and installations. Both standard, permanent type well completion, and dual zone installations have been considered.

A section has been included on setting tools. Discussions, profusely illustrated, have been included on wire line pressure setting tools and the model "B" setting tool.

Detailed operating instructions and procedures for running and setting the packer, as well as working over above and below the packer have been discussed. Details on pulling the tubing when there is pressure between the casing and tubing, is just an indication of the completeness of the manual.

Applications of the packer are profuse, and every attempt has been made to describe many of these applications.

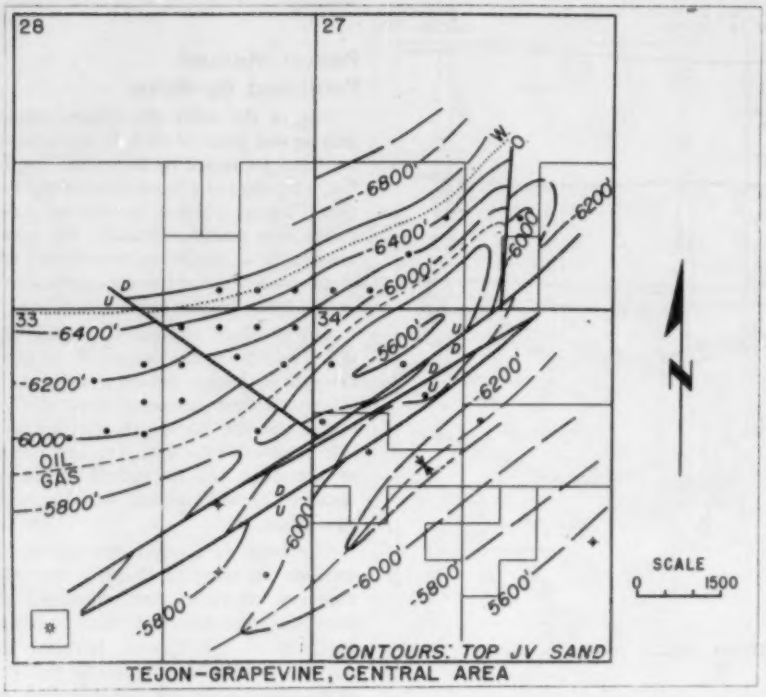

FIG. 6. **STRUCTURE CONTOUR** on top of the JV sand at 200-ft intervals.

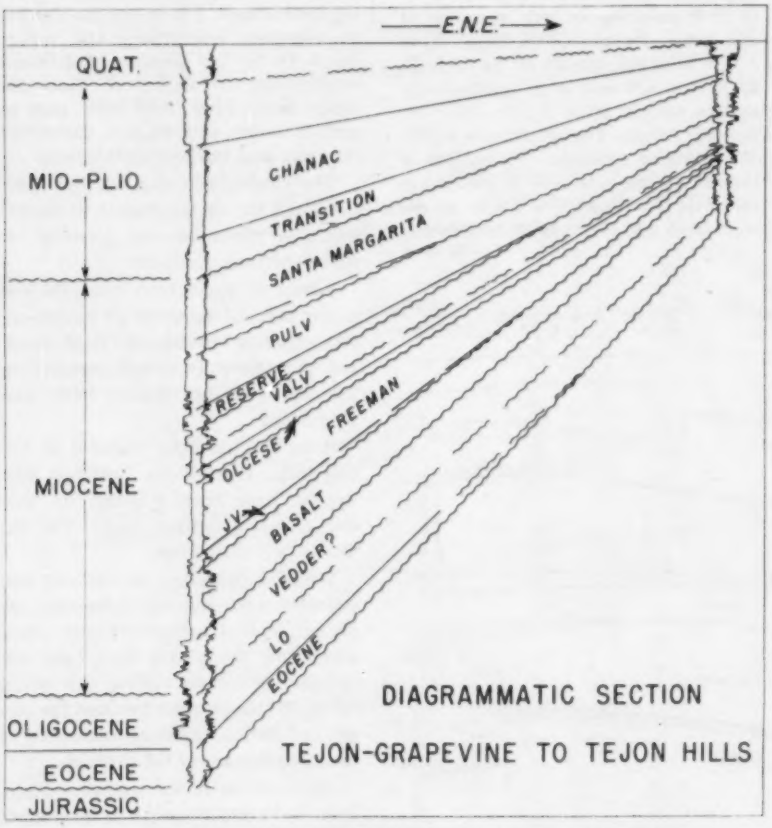

FIG. 7. **PINCHING OF ALL FORMATIONS** is indicated in this east northeast diagrammatic section from the Tejon-Grapevine field to the Tejon Hills field.

Ridge Hill Oil Co. Well Schoettler No. 10, located on the south flank of the JV fold in Section 34, had no Olcese sand in the Relizian section, and the JV Sand was tight and gassy. Production, however, was obtained from a stray Freeman sand of Saucesian age that appears to have a very limited areal extent.

Below the JV Sand lies a Saucesian volcanic section of 1400 to 1800 ft thick consisting of basaltic detritus, basalt flows, ash beds and occasional sand fingers. The thickest known section underlies the JV and Olcese fold in the Central Area. Present evidence indicates the volcanic section to be mainly flow-type material; however, there are some intrusives in outcrop.

Sediments below the volcanics have not as yet been intensively explored but productive in other areas nearby, such as Tejon Hills, Wheeler Ridge and Edison. The diagrammatic section shows the numerous unconformities, wedging of the various formations and lapping out of the sediments against basement.

Under the basalt is a 1500 ft Zemorrian section of fine, hard, massive, somewhat ashy sand. In the southern part of the Tejon Hills field, this sand, locally called "DK," produces 33-gravity oil from a depth of 1500 ft.

Due to poor faunal control, the Zemorrian-Refugian contact is indistinct. A few wells have established a probable Oligocene section of about 1100 ft of silts with a massive basal sand. The zone is characterized by a shallow water Elphidium faunule and megafossils such as Molopophorous. This sand, also, is productive in the Tejon Hills field and in one marginal producer in Section 24, T. 11 N., R. 19 W. Locally this zone is called "LO."

Three wells have established the presence of Eocene at a depth of about 12,000 ft. The Eocene section consists of approximately 1300 ft of shale with one or two prominent sand members.

Underlying the Eocene is a Jurassic basement complex consisting of schists, phyllites and granites. Basement rises from about 15,000 ft in the Tejon-Grapevine field to 3000 ft in the Tejon Hills six miles to the east.

Much of the future exploration will undoubtedly be aimed at testing the thicker sand sections found below the basalt.

Acknowledgment

From the original paper titled "Recent Developments — Tejon-Grapevine Field," presented by the author before the fall meeting of the Southern California AAPG meeting held in Los Angeles, California. ★ ★ ★

Bottom-Hole Pressure Drawdown Determined by Measuring Fluid Levels

Author James Henderson operates accoustical well sounder at the wellhead of a pumping well to make liquid level measurements used in determining productivity index.

Sonic Method Measures

Productivity Index of Pumping Wells

Herbert D. Miller and James R. Henderson

PRODUCTIVITY index tests utilizing a sonic means to measure fluid level and thus obtain bottom-hole pressure drawdowns of pumping wells have been made in North Texas.

Such tests are practical, inexpensive and accurate when the wells tested produce no water. Possibilities of applying this method to wells producing water have not been exploited. The sonic method of determining the fluid level in a pumping oil well consists of generating a sound wave in the annulus and recording the reflections from the tubing collars and from the fluid on a moving chart. Depth to the fluid level is obtained by counting the number of tubing collars and multiplying by the average tubing length. In order to minimize gaging error and increase drawdown, the well should be pumped at as high a speed as is practicable. Data from two similar wells, one tested by sonic means — the other by a bottom-hole pressure gage flow test, are presented.

Productivity index tests, valuable as a basis for a number of predictions about future reservoir performance, were formerly restricted to flowing wells due to the complication and expense of making such tests on pumping wells. Two other methods of measuring bottom-hole pressures of pumping wells are currently in use. Lowering a gage attached to a wire line into the casing annulus sometimes proves to be unsatisfactory because the wire line tends to wrap around the tubing, sometimes resulting in a lost gage. It is also difficult to lower a wire line and bottom-hole pressure gage into the annulus through a conventional tubing head. Attaching a gage below the pump to the bottom of the tubing string is another method. Since this requires pulling the rods and tubing twice for each test, it is rather expensive.

Productivity index is the number of barrels of oil produced per day per pound per square inch of differential pressure between the reservoir extremity and bottom of the well.[1] To measure productivity index, production of the well must be metered and a record made of the change in the bottom-hole pressure of the well during the production of metered fluids. The tests are carefully timed, and if productivity index as the ordinate and time as the abcissa are plotted on log-log graph paper, a straight line usually results. Interpretation of these curves as to type of drive, reserves, etc., has been discussed in the literature.[1]

As measuring production is usually not difficult, the problem of taking a PI test essentially becomes one of measuring the bottom-hole pressure of the test well while it is pumping. In the tests herein presented, an accoustical well sounder was used to measure the height of the fluid level in the well, and from the oil gradient and the height of the column of fluid, the bottom-hole pressure was calculated. Using the oil gradient for calculations was acceptable because the wells were not producing water. So far, this method of pressure measurement by sonic means has been limited to wells producing no water. If water is being produced and hourly pressure measurements are taken, it is difficult to ascertain the percentage of water that is in the casing annulus. It is believed, however, that after a well has pumped for a time, fluid in the annulus will be all oil due to the water settling to the bottom and being pumped off. Still, a great deal of uncertainty is added to the test if the well is producing appreciable quantities of water.

How It Works. The sonic method of determining fluid level in a pumping

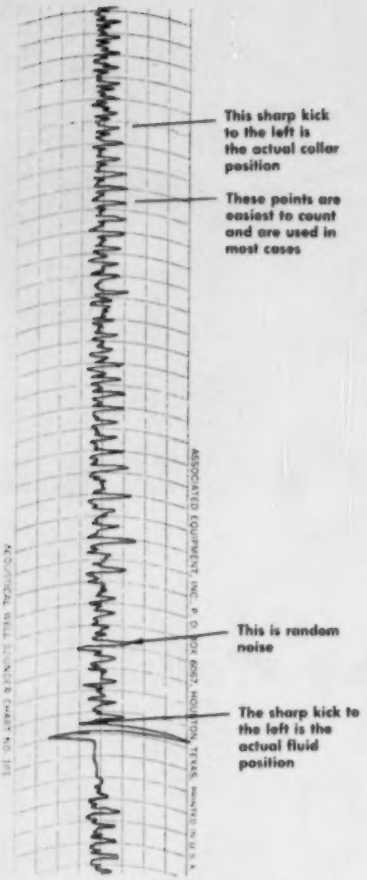
This sharp kick to the left is the actual collar position
These points are easiest to count and are used in most cases
This is random noise
The sharp kick to the left is the actual fluid position
ASSOCIATED EQUIPMENT, INC. P. O. BOX 6057, HOUSTON, TEXAS

FIG. 1. Chart record of tubing collars obtained by accoustical well sounder.

oil well consists of generating a sound wave in the annulus and recording the reflections or echoes from the tubing collars and from the fluid on a moving sheet of chart paper. The initial pressure wave was generated by discharging an explosive at the surface through a special fiitting attached to the well head. The initial wave was keyed to a recording chart so that the exact time interval for reflections of this pressure wave to return to the surface was recorded. In most wells, a record similar to Fig. 1 will be obtained, and the depth to the fluid is determined by mounting the number of tubing collars and multiplying by the average tubing length. The sound wave is generated by firing a blank cartridge into the annulus.

The propagation of a sound wave in a gas is directly proportional to pressure. The higher the pressure, the faster and farther the sound wave will travel. In a high-pressure well, where other conditions are good, it is sometimes difficult to distinguish the fluid reflections from the collar reflections. This is because the collar reflections are saturating the amplifier to the point that it cannot respond to the larger signal from the fluid reflection. Using a smaller cartridge will make the fluid reflections stand out.[2]

In a low-pressure or vacuum well, it is sometimes difficult to distinguish between some obstruction in the annulus, such as a liner or a tubing catcher, and the fluid level. It is then usually necessary to use a higher sensitivity setting and a smaller cartridge. Very low-frequency sounds travel farther than higher frequency sounds if both are propagated through the same media. This phenomenon is utilized through the instrument settings to obtain fluid levels under nearly all conditions.

There are many sources of noise at the wellhead unit such as vibration of the pump or engine, gas leaks, leaky valves or nearby machinery. In order to get a usable recording, the signal impressed on the microphone from the tubing collar and fluid echoes must be greater than that from the random noise. The noise-to-signal ratio is kept low by the proper instrument settings. Care should be taken to make no movements near the wellhead or instrument while it is recording.

Running the Test. Before making a productivity index test, it is desirable to shut in the proposed test well long enough to attain pressure equilibrium, or as long as is practical. The data presented in Table 1, was obtained after a 24-hr shut-in period. After the well has been shut in long enough to attain a constant bottom-hole pressure, the fluid level should be shot with the sonic measuring device.

Pumping speed of the well should be adjusted to that speed which produces a maximum pressure drawdown without injuring the well. Once the test is started, the pumping speed and stroke must not be changed, else the data may be scattered. Length of the test may be decided from the data obtained. It has been found that a test period of 24 hr or longer is desirable, with fluid levels being shot each hour and the fluid produced being gaged at as near as possible the same time.

Measurement of liquid produced is usually the greatest source of error. This is due to the low production rate of 5 to 10 bbl of fluid per hour that is being measured in tanks that strap approximately 2.76 bbl per inch. In order to minimize gaging errors, the well should be pumped at as high a speed as is practicable. This will increase the gage increment (and the drawdown) and thereby reduce probable errors.

Results of Test. Table 1 shows the data obtained by sonic means from a productivity index test of a pumping

TABLE 1. Data obtained by sonic means from a productivity index test of a pumping well in a North Texas field.

Date	Col. 1 Time	Col. 2 Net average prod. (bbl)	Col. 3 Casing pressure	Col. 4 Joints to fluid	Col. 5 Feet to fluid	Col. 6 Feet of fluid	Col. 7 Pressure oil column psi	Col. 8 Pressure gas column psi	Col. 9 HP psi	Col. 10 HP drop psi	Col. 11 Prod. index bbl/hr. psi
1/23/55	10:30 am			41.3	1271	2839	951	2	978	—	—
	11:30	10.35	20	44.2	1360	2750	921	2	943	35	.2957
	12:30	9.66	20	46.0	1416	2684	902	2	924	54	.1789
	1:30 pm	8.97	20	47.0	1447	2653	892	2	914	64	.1402
	2:30	8.28	20	48.0	1477	2633	881	2	903	75	.1104
	3:30	8.97	20	49.0	1508	2602	871	2	893	85	.1055
	4:30	9.66	20	50.0	1539	2571	861	2	883	95	.1017
	5:30	8.97	20	50.5	1554	2556	856	2	878	100	.0897
	6:30	8.28	20	51.0	1570	2540	851	2	873	105	.0789
	7:30	8.28	20	51.0	1570	2540	851	2	873	105	.0789
	8:30	8.28	20	—	—	—	—	—	—	—	—
1/24/55	9:30 am	8.28	15	59.0	1816	2294	768	2	785	193	.0429
	10:30	8.63	15	59.1	1819	2291	767	2	784	194	.0445
	4:30 pm	8.63	12	61.3	1876	2235	749	2	763	215	.0401
	10:30	8.28	12	62.6	1927	2183	731	2	745	233	.0355
1/25/55	4:30 am	8.40	35	64.6	1988	2122	711	2	749	229	.0367
	10:30	8.74	35	65.8	2025	2085	698	2	736	242	.0361
	4:30 pm	8.63	15	67.0	2062	2048	686	2	703	275	.0314
	10:30	8.51	10	68.0	2093	2017	675	2	687	291	.0292
1/26/55	4:30 am	8.56	15	69.0	2123	1987	666	2	682	296	.0289
	10:30	8.38	10	70.5	2170	1940	650	2	682	316	.0265

Fluid Gradient: 0.335 psi/ft
Pressure Datum: —2850 ft sub-sea.
Well pumping with a 48-in. stroke at 16 strokes per minute.

The Authors

Herbert D. Miller was graduated from the University of Oklahoma in 1941 with a BS in petroleum engineering. He was employed by Amerada Petroleum Corporation in 1947, and is now chief engineer for Amerada in the East Texas district. Miller is vice chairman of the East Texas Chapter of AIME.

James R. Henderson is a 1955 petroleum engineering graduate of Texas A&M College, where he was editor of the school's engineering magazine. He is now a graduate student in physics at A&M and has been employed during the summer as an engineer for Amerada Petroleum Corporation. He is a junior member of AIME and is also a member of Tau Beta Pi.

well in a North Texas field. The first column shows the times at which the fluid levels were measured. The second column shows the net gaged production, and the third column shows pressure on the casing. The depth of the fluid level (Col. 5) was obtained by multiplying the number of tubing joints to the fluid level (Col. 4) by the average length of the tubing joints. Column 6, the height of the fluid column in the annulus, is the difference between the depth to the pressure datum and the depth to the fluid level (Col. 5). The bottom-hole pressure, as recorded in Column 9, was then the sum of the pressure due to the fluid column (Col. 7), the casing pressure (Col. 3) and the pressure due to the weight of the gas column (Col. 8). The productivity index was then calculated as barrels per hour per hourly psi drop in pressure.

TABLE 2
Data obtained with a bottom-hole pressure gage from a productivity index test of a flowing well offsetting the well on Table 1.

Col. 1 Time	Col. 2 Pressure psi	Col. 3 Pressure drop psi	Col. 4 Net avg. production (bbl)	Col. 5 Production index bbl/hr psi
11:00 am	1434	52	27.52	.529
12:00 noon	1412	74	21.62	.292
1:00 pm	1399	87	19.59	.225
2:00	1389	97	18.28	.188
3:00	1382	104	16.45	.158
4:00	1373	113	14.87	.132
5:00	1372	114	14.87	.130
6:00	1370	116	14.56	.126
7:00	1369	117	13.33	.114
8:00	1364	122	13.33	.109
9:00	1360	126	13.52	.107
10:00	1357	129	13.04	.101
11:00	1355	131	11.98	.0915
12:00	1353	133	12.46	.0937
1:00 am	1351	135	12.18	.0902
2:00	1349	137	10.75	.0785
3:00	1348	138	10.75	.0779
4:00	1346	140	11.50	.0821
5:00	1344	142	12.65	.0890
6:00	1342	144	11.90	.0826
7:00	1340	146	11.90	.0815
8:00	1339	147	10.07	.0685
9:00	1337	149	8.34	.0560
10:00	1331	155	12.60	.0813
11:00	1326	160	14.18	.0886
12:00 noon	1321	165	12.22	.0741

Gradient: 0.322 psi/ft
Well flowing on 26/64-in. adjustable choke.

Table 2 shows the data obtained from a flow test of a well offsetting the test well of Table 1. A bottom-hole pressure bomb was used to measure the pressures in this test. Note the similarity of the productivity index curves, Fig. 2 and 3. The two wells were approximately 1350 ft apart and were producing from the same formation. Furthermore, the wells were developed at about the same time and had been producing an equal length of time. The tests were made two months apart. Soon after the test, the flowing well was put on the pump.

As the wells were similar in nature and yielded productivity index curves having the same slope, the two tests were thought to illustrate the validity of taking productivity index tests by sonic means. The method has been extensively applied in this field with satisfying results.

Because the search for oil becomes more intense each year, more and more fields are being brought in, "on the pump." Productivity index tests of pumping wells should be valuable in determining the characteristics of the future production of such fields.

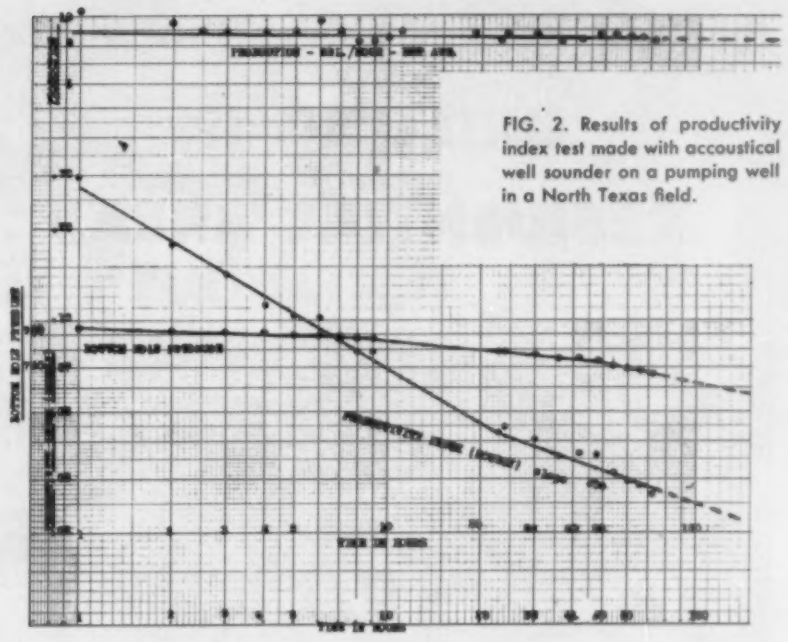

FIG. 2. Results of productivity index test made with accoustical well sounder on a pumping well in a North Texas field.

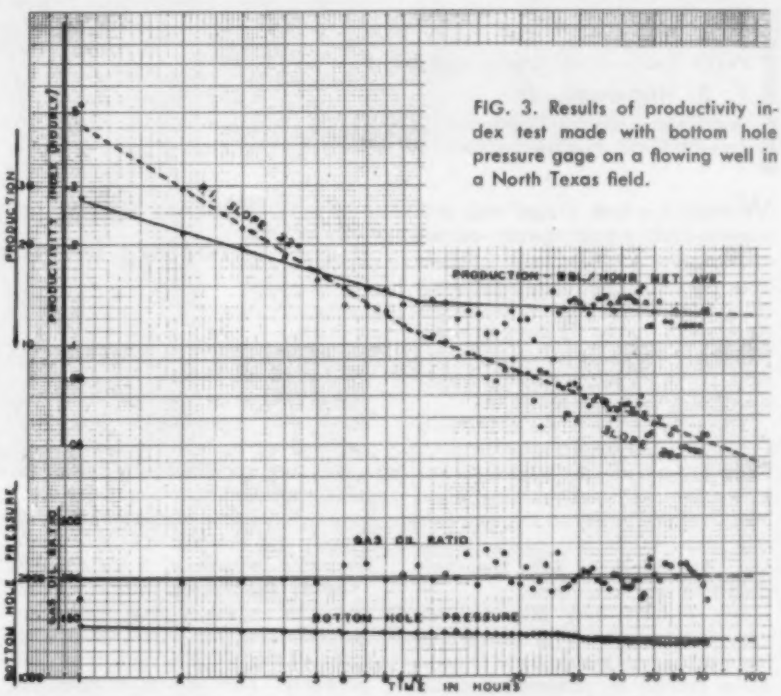

FIG. 3. Results of productivity index test made with bottom hole pressure gage on a flowing well in a North Texas field.

References

1. Millikan, C. V. and Beardmore, H. F., "Significance of Declining Productivity Index," *AIME Transactions*, Vol. 155 and 160, petroleum division, AIME, New York City, 1944 and 1945.

2. *Operation and Maintenance Manual*, Associated Equipment, Inc., April 15, 1955. ★ ★

Straight AC Rig Solves Problem of DRILLING IN RESIDENTIAL AREAS

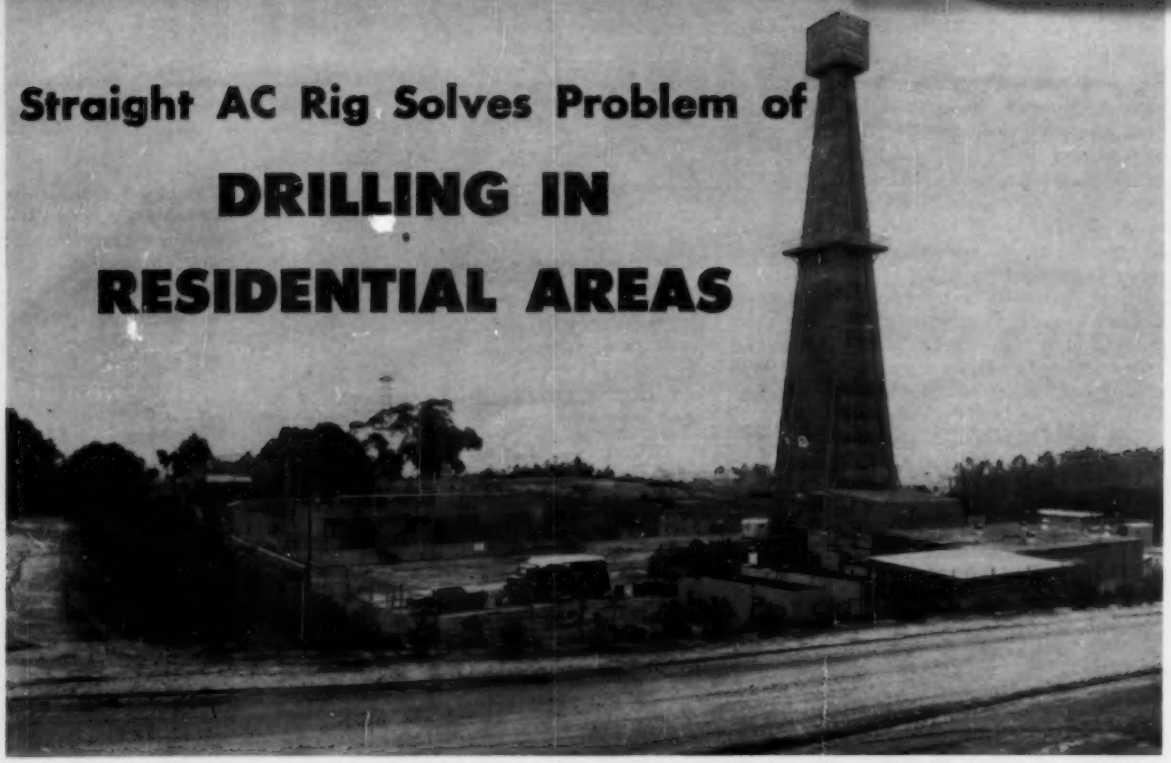

FIG. 1. **Site of Universal Consolidated Oil** Company's well drilled by Sun Drilling Company on 20th Century Fox Studio lots near Beverly Hills, California.

E. S. Knox
PAKCO Company, Los Angeles, California
E. E. Hogwood, Jr.
Westinghouse Electric Corporation, East Pittsburgh, Pennsylvania

P 422.35

Noise, safety and appearance are major factors in meeting regulatory codes.

WHEN you drill a deep well in a populated residential district of our modern cities, you have more problems than those normally encountered. Noise from the rig must be minimized. Appearance of the rig must be made pleasing to the residents and motorists. And, above all, safety assumes greater significance than ever before.

These were some of the added problems facing Universal Consolidated Oil Company and the Sun Drilling Company when they started drilling on the 20th Century Fox studio lots near Beverly Hills, California, nearly a year ago. Since then, six wells have been drilled on this urban lease.

A new, heavy-duty alternating-current, electric-powered rig offered a solution to the principal problem of noise. Noise created by acceleration of the drawworks during hoisting, handling of drill pipe when changing a bit, the "squeal" of the brakes when "paying off" line during drilling were quieted by a mat or batting-type material placed over the entire derrick structure. Also, all equipment was enclosed inside a housing structure to further silence the rig noises. Fig. 1 shows the totally enclosed A-C drilling rig at its Beverly Hills site. Note than even shrubbery was planted around the steel fence enclosure. Such a location is more costly than drilling in an open field, but this is one way of getting the oil. Several directional wells, however, are usually drilled from one location to recover the initial investment and to meet community restrictions that prevent placing derricks and locating wells throughout the residential area.

Safety Big Factor. Safety requirements in an urban area usually are more stringent than in remote areas because of the added danger to life and property. This electric-powered rig offered a solution to these problems by conforming to these safety codes. These codes are written for the most extreme cases, and their interpretation hinges directly on the location of the installation. For this reason practices established on remotely located drilling rigs could not be employed.

In California, a drilling location is classified as a Class I Group B Hazardous Area within 50 ft of the hole being drilled. With this factor in mind, the application of equipment for proper appearance as well as safety requirements follow this type of schedule:

1. Overall layouts and structures are submitted to the Planning Commission, Fire Departments and other interrelated agencies.
2. Electrical layouts and schematics are submitted to the affected state, county and city electrical agencies.
3. If the design and selection appear to meet all requirements, a permit is then issued authorizing work to proceed.
4. Equipment is then installed under the affected agency inspection both during construction and after completion.

Because of the Class I Group B classification of the location and the fact that the rig is enclosed, underground cable and conduit is used

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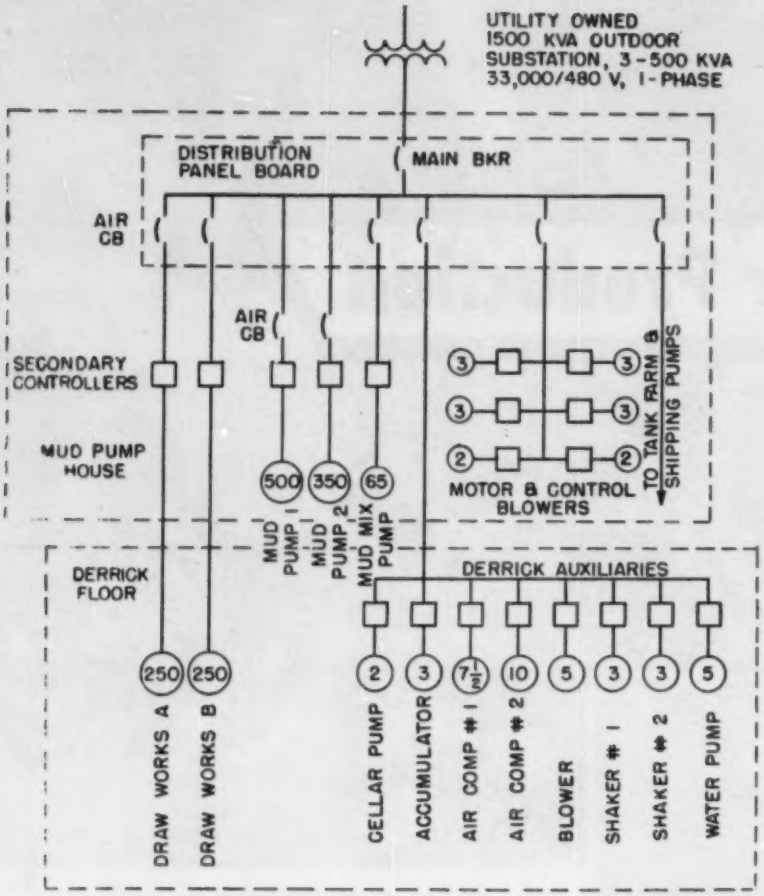

FIG. 2. **Single line schematic** diagram of electrical hookup and equipment used on this A-C drilling rig.

throughout. Most agencies are extremely reluctant to consider any type of installation that doesn't meet the highest known standard of safety; therefore, the use of portable cable was not advisable.

Enclosing the entire derrick structure and mud house with nylon-covered, spun glass, fireproof batting considerably reduces the noise level of normal drilling operations such as accelerating the drawworks and handling stands of pipe when changing a bit.

Equipment and Operation

The derrick structure is a conventional type completely covered with a nylon fireproof batting material to help eliminate the derrick floor noises of the drawworks, rotary table, and handling of drill pipe when coming out of or going into the hole. Outside of the structure is painted sky blue with fireproof paint. The two 250-hp, three-phase, 440-v wound rotor drawworks motors are located inside the derrick floor enclosure and are chain-connected into the jack shaft of the drawworks.

The mud pump house is a completely separate building located several yards away from the derrick outside the hazardous area. This semi-permanent structure is also covered with the blue, fireproof nylon batting to combat the noise problem and lend a pleasant appearance to the drilling site. In the mud pump house are the main mud pumps and motors, the manual control and secondary resistors for each of the mud pumps, the twin magnetic drawworks controllers and the main 440-v distribution panel board. The mud pump house is equipped with an axial flow fan and a 5-hp motor to help remove heat from the building.

Located just north of the mud pump house are the mud tanks and the mud shed for storing dry mud. A 65-hp mud mixing pump motor and pump is located near the derrick and mud mixing tanks.

Power Supply. Power is supplied to the drilling site at a utilization voltage of 440 v by the City of Los Angeles Department of Water and Power. The voltage reaches the outdoor power company substation at 33 kv and is stepped down to 440 v through three 500 kva, single-phase transformers.

The 440-v power is fed by underground cable into the low-voltage metering and distribution switchboard, which is located in the mud pump house. From there it goes to the various main and auxiliary drives by underground conduit and cable. Lighting distribution is also by underground cable from the switchboard to the various hazardous locations.

There are five main drives and a number of small auxiliary drives. The single-line diagram for the rig is shown in Fig. 2.

Motors. The major drive equipment consists of the following: Two 250-hp, 900-rpm, 440-v, three-phase, 60-cycle, 40-C rise wound rotor drawworks motors with enclosed collector rings, one 350-hp, 900-rpm, 440-v three-phase, 60-cycle, 40-C rise, wound rotor, force-ventilated mud pump motors, 1 500-hp, 900-rpm, 440-v, three-phase, 60-cycle, 40-C rise, force-ventilated mud pump motor, and one 65-hp, 1200-rpm, 440-v three-phase, 60 cycle, 40-C rise and mixing pump motor.

Controls. Electrical controls incorporated include: One set of "twin drawworks" magnetic controls and secondary resistors, and two sets of manual mud pump motor controls, one for the 350-hp pump motor, and one for the 500-hp pump motor.

The rotary table is driven from the drawworks by means of a chain drive. The two 250-hp drawworks motors are of the enclosed collector ring, or "explosion-resisting" type. The secondary leads of the motor are brought out through the shaft into an overhung housing on the front end shaft extension of the motor that totally encloses the collector ring assembly. Two large conduit boxes for the primary and secondary leads are attached on the side of the motor for lead connections to the 440-v three-phase power, and the secondary resistors are located in the mud pump house. Dripproof, protecting screens are provided on all openings to prevent entrance of rodents into the machines when they are shut down.

These two drawworks motors are mounted on a common skid-type bedplate behind and parallel with the drawworks. The rear end shaft extensions of the motors are coupled to a counter shaft supported by two pedestal bearings on which is mounted a quadruple chain sprocket for driving the drawworks.

The two main mud pump motors are identical except for rating; one is 350-hp, the other 500-hp. These motors are equipped with force ventilating covers and top-mounted blower and blower motor. The collector rings are located inside of the motor frame rather than

in enclosed collector housings as were the drawworks motors for two reasons: (1) The mud pumps at present are located in the pump house several yards from the derrick floor and out of the hazardous area, and (2) should the occasion arise where this motor is operated in a hazardous area, safe air can be piped to it because it is force-ventilated by a top-mounted blower and motor.

Ventilating air enters the top of the motor frame, is distributed to each end, and is discharged out the center side of the motor on the side opposite the conduit boxes. The forced ventilation allows continuous operation of these motors at low speeds.

Mud pump motors are equipped with two bracket-type and one pedestal-type ring, oil-lubricated sleeve bearings for the "V-belt" drive of the mud pumps. Each motor, pedestal bearing, and slide rails are mounted on a rugged skid-type bedplate for ease of transportation when it becomes necessary to move this equipment to a new location.

The 65-hp mud mixing pump motor is a rewound, enclosed collector-wound rotor type motor. This motor is self ventilated and is also provided with rodent-proof screens.

Main Drive Electrical Controls. The main controls for the drawworks and mud pump motors may be described as follows: "Twin drawworks" controllers are of the magnetic air-brake reversing type. As implied, these controllers are made up of two separate control cabinets—one for each of the 250-hp motors. Each controller consists of a reversing primary contactor, a set of force-ventilated speed-regulating resistors, and the secondary magnetic control, all mounted on a separate oil field skid-type base. Primary protection is provided for these motors by air circuit breakers located on the distribution panel.

Only one driller's master switch is required to operate either one of the DW motors individually or both simultaneously. This is accomplished by means of a relay cabinet mounted on the side of one of the drawworks controllers and a three-position explosion-proof selector switch mounted at the driller's station. The relays are operated by the master switch on the drill floor, and the selector switch allows selection of either or both drawworks motors to be operated at any given time.

"Twin drawworks" controllers were selected so that one of the motors and its associated magnetic controller could be moved to another job, if necessary, without the necessity of purchasing a new magnetic controller. Purchase of a new master switch could be made when the two motors and control are separated. This gives the maximum flexibility of equipment for the lowest overall investment if the equipment has to be separated.

Normally, when the rig is drilling, the operator will turn the drawworks selector switch to one of the drawworks motors, either motor A or motor B. Then by engaging the proper clutch and manipulating the drawworks master switch, the rotary table speed is controlled.

Under hoisting conditions, the driller selects motors A and B and, by means of the same master switch, controls the speed of both drawworks motors simultaneously. The load is taken from the slips smoothly and without sudden shock to the derrick and mechanical equipment. The first four points of acceleration by the controller are controlled manually by the positioning of the master switch; however, the last four are timed by definite time-limit relays, which prevents excessive current peaks and the possibility of exceeding motor pull-out torque when the master switch is quickly moved to the full speed position as is frequently done during hoisting.

Also provided at the driller's station is an explosion-proof emergency stop pushbutton that can shutdown the entire rig and two ammeters for measurements of drawworks motor amperes.

Characteristic curves for the drawworks motors are shown in Fig. 3. It will be noted that smooth application of motor torque is possible for acceleration of the hoisting load by means of the usual wound rotor motor characteristics. The drawworks motors are rated to permit high momentary and hoisting cycle loads without exceeding motor pull-out torque and stalling.

Mud Pump Controllers. Controllers for the 350 and 500-hp mud pump motors are identical except for rating. Each consists of an air circuit breaker, a manual drum controller, a set of force-ventilated, speed-regulating resistors and an ammeter, all mounted on a rugged skid-type base.

Primary protection is provided to the mud pump motor by the air-circuit breaker. This manually operated breaker is equipped with instantaneous trip elements that will remove the motor under short-circuit fault conditions, and an undervoltage trip element that removes the motor on low A-C voltage. The breaker is locked out by an electric lockout feature interlocked with the drum controller assuring that the drum controller is in the "off" position before application of primary 440-v power to the motor is possible.

The manual drum controller provides eight operating speed-torque curves for regulating the speed of the

Offshore Oil Search Costs Are High

There's more than a half-billion dollars somewhere in the Gulf of Mexico that oil men would like to get back to balance the books.

The money represents the investment that oil men from Texas and elsewhere have in the offshore areas, or "tidelands," of Texas and Louisiana.

Texas public schools are a major beneficiary of offshore operations, according to the Texas Mid-Continent Oil & Gas Association in an Oil Progress Week summary.

Texas' Permanent School Fund has received $57,076,790 from operators in lease and bonus money for the right to drill on 588,464 acres in Texas' offshore area, General Land Office figures show. In July, operators bid $8,437,462 for federal leases on 149,760 acres which lie beyond the 10½-mile Texas boundary.

Cost of drilling an offshore well may run $1,000,000 or more but operators continue their risky search in hope of finding the big field to offset the expense of their failures.

There have been about 25 wells drilled in the Texas Continental Shelf area.

The first oil discovery off Texas was made in 1941 and has since been abandoned. All drilling activity ceased during the litigation over ownership of the tidelands but picked up after the bill recognizing state ownership was signed by the President in 1953.

Since resuming Shelf drilling off Texas, operators have completed three successful wells. The first discovery was made in July 1954 off Padre Island by Standard Oil Company of Texas.

In February of this year Gulf Oil Corporation brought in an oil well off Corpus Christi and in April the Pure Oil Company completed a producer 12 miles southeast of Galveston.

Louisiana drilling has been highly successful, resulting in about 50 oil and gas discoveries.

Exploration—such as seismographing—in the Continental Shelf of Texas and Louisiana has been costly to the operators. An estimated $100,000,000 has been spent in locating approximately 250 structural formations.

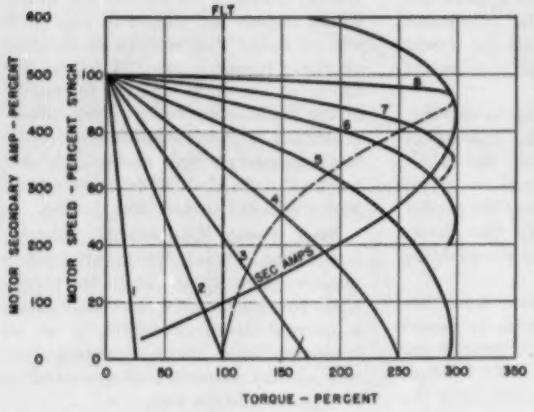

FIG. 3. **Speed-torque curve** for one of the 250-hp, 440-v, 3-phase, 60-cycle drawworks motors.

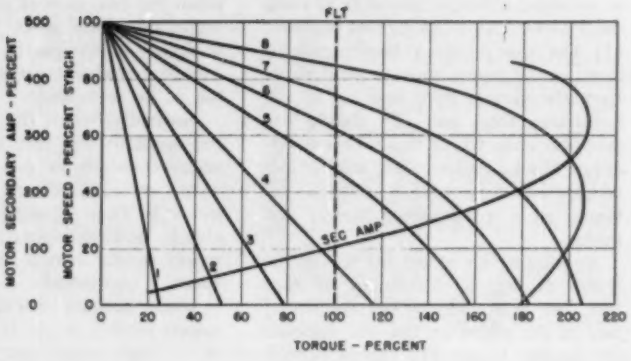

FIG. 4. **Speed-torque curve** for the 500-hp, 440-v, 3-phase, 60-cycle CW motor for the mud pump drive.

mud pump to give the desired mud flow and pressure. The speed regulating resistors are proportioned to give what is considered the most satisfactory regulation for the particular combination of pump, pump drive and motor. When the pump, motor and resistors are coordinated as a unit, satisfactory performances are obtained over the full range from zero to full pump speed and from zero to rated pump pressures.

The mud pump motors are force ventilated; therefore, sufficient air is moving to allow operation down to very low speeds at rated torque. This forced ventilation also allows some operation at overloads for short periods of time without excessive reduction in motor "life."

Resistors of the mud pump control give typical curves as shown in Fig. 4. It can be seen from these typical curves that when the motor is operating on any speed point, the characteristics are such that predetermined limits of pressure are assured when excessive operating requirements are met or a plugged bit encountered. Operation on point 8 provides a definite torque limit (or limit in load torque build-up) so that protection to the motor is provided. If the load build-up is caused by a plugged mud line or bit, the motor torque is at or near its maximum value to assist in breaking through the trouble-making plug. The motor current, however, is limited to a value less than the usual 600 per cent full-load current at stall on this point, which reduces the motor heating. The motor may be operated at stall for a few seconds. The loss in efficiency at full-load torque is justifiable to achieve this feature.

Why A-C Power? Before drilling operations could proceed at a site adjacent to the city limits of Beverly Hills, it was necessary to reduce the objectionable features of a drilling rig that might cause complaints by residents and other members of the community. First and foremost of these objectionable features was noise.

Drilling engines are the largest single source of noise; therefore, it was decided that the quietest type of drive would be the electric drive. Utility-owned A-C power was readily available from the nearby power company high-tension lines. After the Universal Consolidated Oil Company's engineers had decided on the maximum depth to be drilled and had selected the size of the mechanical equipment, drawworks, pump, etc., with the load requirements indicated by this selection, it was decided that the straight A-C rig would perform almost equally as well as A-C to D-C. The A-C rig, therefore, was recommended at an appreciable saving in first cost. ★ ★ ★

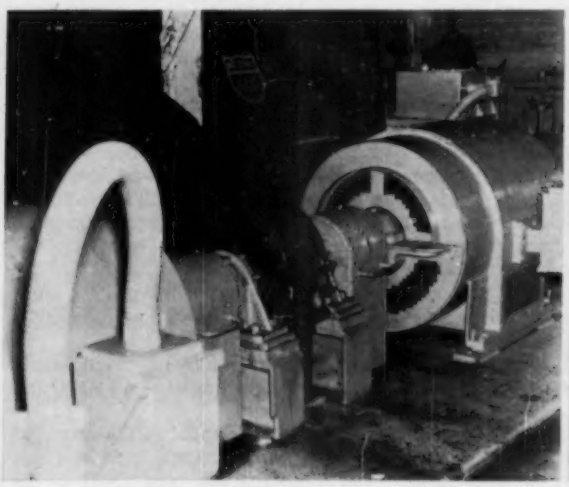

FIG. 5. **"Twin drawworks" drive** utilizing two 250-hp, enclosed collector ring wound motors are connected to the drawworks by a chain drive.

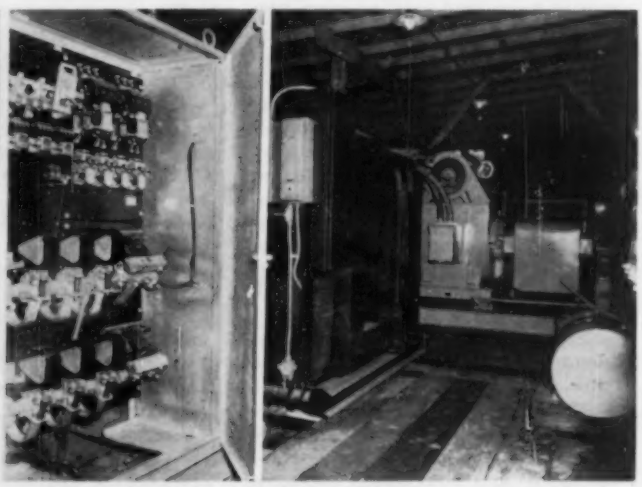

FIG. 6. **Magnetic drawworks controller** (left) inside the pump house and one of the manual mud pump controllers (center). In the background is a 500-hp mud pump motor.

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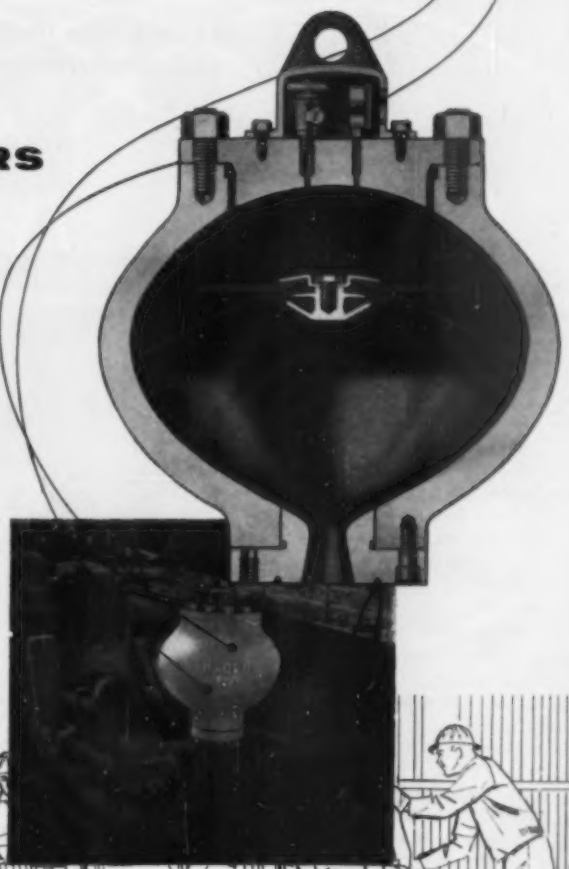

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Part 6 | Injection Well Completions and Selection of Surface Equipment

Elements of Water Injection

Basic guide in dealing with surface and subsurface mechanical problems

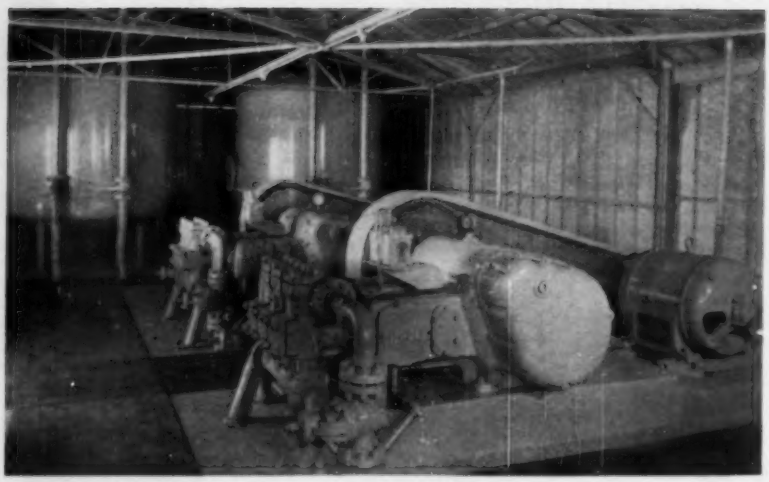
J. Randolph Buck
Consultant, Dallas, Texas

THE manner in which wells can be drilled, completed or recompleted, and equipped is known, at least in a general way, at the time when plans for the flooding pattern congeal. The completion and subsequent operation of wells introduces cost factors that contribute in determining well spacing, oil recovery, and future profit. This relationship is but another example of the interdependence of the various aspects of this many-sided problem. While planning a flood would be simpler if each phase could be separately attacked and solved, the fact of interdependency is really an advantage, since it makes possible the neutralization of unfavorable factors.

There are no standard ways for completing wells for waterflooding. There is little uniformity in equipment selection and operating methods, even in the same field. Each producer has a wide latitude for independent decisions in his own program. Failure to consider all the choices open in a given situation is paid for out of profits. Flooding, being the underground proposition that it is, cannot be completely predetermined. The "pilot flood" helps fill this gap.

Pilot Flood

A pilot flood essentially is a cautious beginning to more extensive field operations. Well completion methods are evolved, the ability of the formation to take water is determined, and the general success of the oil displacement process is evaluated from the subsequent performance of wells in or near the test area. For edgewater drive, the conversion of a single downdip well to injection service may be adequate to make a reasonable test for floodability. For the 5-spot pattern, the usual square arrangement of wells with four injection wells at the corners and one producer in the center may be satisfactory but not foolproof. Too much hinges on the solitary producer. A more significant test employs two adjacent 5-spots which would include six inputs and two producers. The least convincing test places one input in the center of a ring of producers. In this case, the beneficial effects of the injected water are distributed over several wells and the results may be indiscernible. While establishing a pilot flood is not necessary in all cases, it is a prudent method for minimizing risks attending a larger investment.



Selection of surface equipment is just as important as selecting subsurface equipment. Above is a well-designed and equipped installation employing two motor-driven, triplex pumps for water injection service. Two pressure-type filters are shown in the background.

Functional units in a flood project are the (1) water supply, (2) water treating facilities, (3) water distribution system including injection wells, and (4) usual production equipment including producing wells. The supply and treatment of water will be considered in a later section. Items (3) and (4), injection and production equipment, will be discussed below.

Injection System

Pressure — key to control. For present purposes, assume that there is an adequate supply of suitable water in the "clear" tank ready for distribution. In some instances, this water will flow by gravity into the producing formation exposed in the injection wells. In most cases, it is necessary to pump the water into the sand to increase the in-

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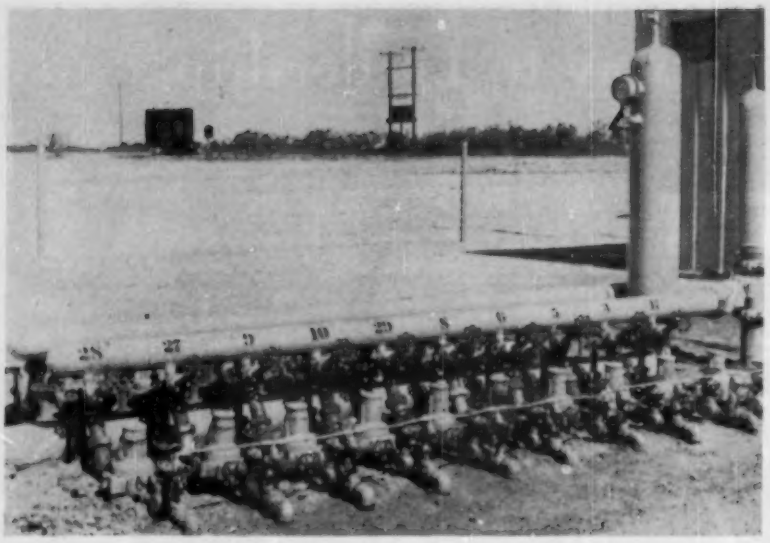


Water injection manifold for centralized control. A Y-connection is used ahead of each meter to provide a choice between separate high and low-pressure supply manifolds. Note a single, interconnected gage line (foreground) permits measurement of injection line pressure to each input well by a single gage.

take rate. The desired rate of water entry is a value calculated from the reservoir pore volume and the planned flooding life. Pump pressure is the control whereby the operator can regulate progress of the flood. There are limits to how high the injection pressure can go without damage to the well and the flood. A commonly used rule is to limit the pressure at the sand face to between 1 and 1½ psi per foot of depth. Higher pressures tend to open fractures in the pay, known as "pressure parting." The maximum safe pressure for each injection well should be determined by well tests. Assurance that pump pressure will not exceed this value can be had by installing a pressure release bypass valve on the pump manifold.

Pressure pumps. The use of duplex and triplex pumps have been popular in the past for injection service, although rod line and other types of pumps have variously been employed.

Pressure pumps are not required when the input wells will take sufficient water under vacuum or when pressure generated at the water supply well can be directly applied to injection.

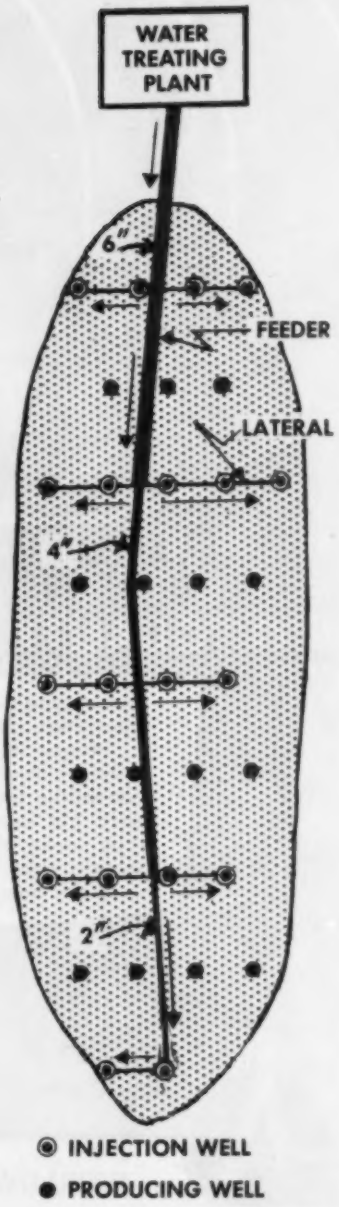
Maintenance costs can be reduced by taking advantage of design features such as porcelain pistons on reciprocating pumps when corrosive water is being handled.

Surface piping. In laying out the water distribution piping, it is advantageous to run separate lines to each well from a central high-pressure manifold. Each line is equipped with a pressure gage, control valve and water meter. The advantages derived from frequent observation by the field superintendent justifies the arrangement. A simpler installation might be to run a single large diameter feeder line from the pump station through the area with 1½-in. or 2-in. lateral lines to the individual wells. Orifice plates rather than meters might be installed at the wells. It is preferable for pipes to be over, rather than under-sized to reduce the corrosive action of high velocity fluids. Plain, cement-lined, and plastic-lined steel pipe have been used in distribution systems. A strainer at the wellhead is recommended, particularly when some plastic coatings are used, to retain chunks which may peel from the lining. Plastic pipe may be used in suction or low pressure systems.

Use of old producers. The completion of the injection well warrants serious consideration. For deep fields, wells must already be in good mechanical condition since the cost of deep conversion work or additional drilling will be prohibitive. For shallow fields, a choice may exist between the conversion of old producers and new wells. Below 1200 to 1500 ft, old producers tend to appear more attractive when they fit a spacing pattern. Old wells can be conditioned by a thorough clean out, using wall scrapers, and washing with mud acid, kerosine or gasoline. Despite examples to the contrary, an old well previously used as an air or gas injection well is a poor prospect for water injection. Water will flow easily through the established gas-filled channels in the sand to the producers, thereby preventing the formation of an effective oil bank.

Casing. Where there are field rules by a regulatory body with respect to completion methods, these must be observed or else exceptions requested. The reasons for original rules may no longer exist under depleted conditions in the reservoir. Economies can sometimes be realized by introducing differ-

Field development map indicating use of main feeder line running length of field with laterals supplying groups of input wells. Water measurement and control equipment are located at each wellhead.



ent and currently applicable ideas. While casing and tubing all holes is conventional practice, many is the flood where only a few feet of surface pipe, no casing, and tubing cemented at the top of the sand comprises the subsurface installation. The savings, if possible, are worthwhile. In some projects, water is injected through casing and without tubing. Casing of about 6 in. in O.D. is probably the most commonly used, although the range is from 4-in. line pipe for shallow work to 7-in. The intended life of the project helps decide whether or not both casing and tubing are actually needed.

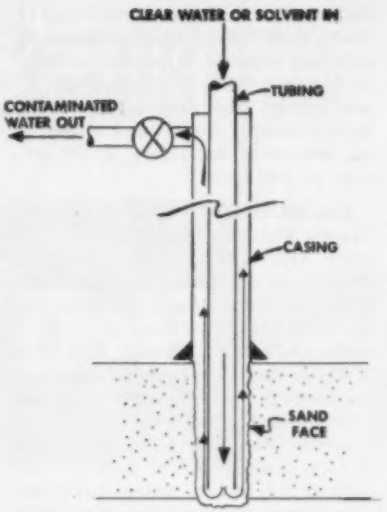
Back-flushing. Whatever tubular program is adopted, there must be some provision for back-flushing the injection well. Back-flushing includes washing the sand face and getting returns out through the well. Purpose is to remove sediments, precipitates, or bacteria from the sand face whenever deposited in sufficient quantity to reduce the water intake rate. When the annulus between the tubing and casing is closed, 1-in. wash pipe with jetting holes opposite the sand can be run inside 2-in. tubing and returns obtained between the tubing strings. Back-flushing on some regular schedule is good operating practice.

Gravel packing. With regard to formation plugging, it is an effective device to gravel-pack the open hole below casing or cemented tubing. This is especially helpful during the early stages of a pilot flood when water treatment methods are on trial. If plugging occurs, the pack can be readily washed out and remedial action taken before extensive damage has occurred to the formation itself.

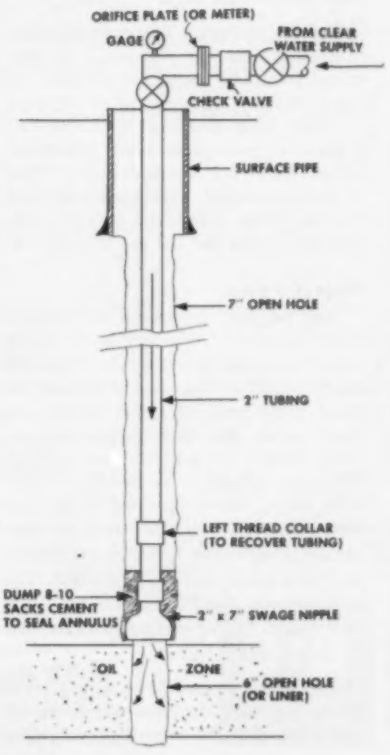
Dual purpose wells. Injection wells can serve doubly as supply wells. With packer set below the water bearing sand, water enters the casing through perforations and is brought to the surface for measurement and injection down through tubing. The hazard is that packer or tubing leaks can destroy the accuracy of measurements or contaminate the pay zone with untreated water. In another type of hookup, water can be injected in controlled quantities into two or three separate zones by using parallel or else concentric (telescoped) tubing strings with appropriate packers. From the workover viewpoint, pulling telescoped tubing is more straightforward than parallel strings.

Shooting. The question of shooting injection wells with explosives is both a personal preference and an area problem. The object is to increase the effective hole diameter. This same end can be achieved by underreaming. An old program has been to shoot the input well selectively, that is, to give the tighter portions of the pay heavier shots. In general, it can be said that there is more reluctance to shoot an injection well than a producer. In the Mid-Continent area shooting has, in the past, been more prevalent in Kansas than in Oklahoma or North Texas.

Water injected other than in the pay serves no useful purpose. The selection of casing, packer, and cementing points must be carefully made to protect the injected water from old gas sands, thief zones, or shale which overlie the oil-saturated section. Sand-shale boundaries are danger points.



Backflushing between tubing and casing to wash or dissolve plugging materials from the sand face in order to increase water intake rates. Note in sketch, above, direction of flow can be reversed.



Example of a simple completion of an injection well using cemented tubing in an open hole.

Production Equipment

The choice of production equipment for a waterflood does not differ radically from that for normal primary production; however, there are unusual features to be recognized. In many cases, producers are completed in the same manner as injection wells.

Flowing vs pumping. Wells may be pumped or flowed. Flowing a flood requires that sufficient pressure be built up in the reservoir with injected water to raise the liquid level to the surface at the producing wells. Flowing requires least investment. Casing may be eliminated in some fields along with rods, pumps, jacks and other costly surface equipment. But flowing is a slow process compared with pumping. Accordingly, it is usually avoided. If the well is to be pumped, it must be both cased and tubed in all situations. Flowing might best be reserved for deep floods where pumping costs would be intolerable or for the final stages of a conventional flood in the effort to lower the economic limit.

Pump selection. The heart of pumping equipment selection lies in the balancing of productive life with corrosion and present and future capacities. Although oil production decreases after the peak rate of the bank stage, total liquid production increases due to the exponential increase in water production. Provision must be made for the maximum loads at the initial installation or else arrangements made for equipment interchange later on. It is unfortunate but true that if a pump cannot handle all the liquid, the well will deliver mostly water. Proper sizing of equipment extends from the surface power and jack to the subsurface pump. For example, a well producing 10 bbl of oil per day cut 95 per cent will produce 190 bbl of water. A rod-insert pump usually does not handle this much fluid through 2-in. tubing. Since three-fourths of all pulling jobs may be expected for pump difficulties,

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the use of a tubing pump might not be practical over the long haul despite its increased capacity. A possible solution in this case would be to start with insert pumps then to change over to tubing pumps in the later stages to accommodate the larger liquid volmes at that time.

Gas lift. Gas lift provides the answer to some lifting problems for the deeper areas. Gas at sufficient pressure must be assured. Gas lifting may not be expected to work satisfactorily for low gravity crudes or for those where emulsions are readily formed. High fluid levels in the well associated with high productivity are necessary. Continuous flow is desirable to reduce operating difficulties. Some 250 bbl of fluid per day are required to maintain continuous flow in 2-in. tubing. To operate from the greater depths, more gas must be injected. This lessens the density gradient, increases fluid velocity and friction which forces an increase rather than a decrease in the flowing bottomhole pressure. Less production results. For gas lifting deep wells, large tubing sizes are used and higher well productivities are demanded.

Fluid pumps. The fluid pump, or rod-less pump, is worthy of consideration in making economic comparisons. On occasion, they possess distinct advantages, such as in river bottom areas subject to inundation. Costs of massive concrete foundations and substructures to elevate beam pumps can become excessively high.

Central powers. Central powers are still widely used in the older shallow areas. In many cases, the decision to use them has been a matter of "making do" with what is already available and in place. Central powers enjoy an initial advantage which vanishes when some of the connected wells pump off and yet this large unit must be kept running to service the last producing well.

Project Power

Gas supply. A source of reliable power is necessary to any flood operation. It should be recognized that the supply of field gas diminishes as the flood progresses. Another source of gas must be developed before a crisis is reached, if gas is to continue as fuel. When electricity is available together with some background of experience with electricity in the area, an economic comparison between electrification and gas is certainly justified. The comparison should include not only investment and operating costs but also a "down time" factor.

Electricity vs gas. The installation of electric motors can show numerous advantages over the internal combustion engine in some cases. Three-phase equipment is exceedingly rugged and dependable. An electric motor can be assumed to last for the life of the project. Repair labor and material costs are relatively low. Because of the various sizes and ratings, efficient operation can be planned for all stages by interchanging motors between wells to best fit the immediate needs. Through speed control, rod breakage can be reduced. Automatic controls reduce labor costs under intermittent pumping conditions. The initial investment comparison of gas engines with electric motors will probably favor the motor. The offsetting disadvantages are most likely to arise out of consideration of the proximity of the lease to existing power lines, the transmission and distribution equipment costs, and the prevailing electric rates as compared with gas costs. The larger the flooding project, the more likely does it become that electrification will prove itself to be more economical.

Other Considerations

Well testing. It is important to observe that well testing assumes greater importance in flooding work than in routine primary production. More frequent tests must be made on individual wells to note the first appearance of water and to keep informed on the water-oil ratio characteristic upon which the success of the flood may depend. To provide for testing, by-pass connections can be installed at the wellhead for use with portable test equipment. Some operators run separate lines to the tank battery and provide an extra tank for testing purposes. A 24-hour production test on each well every two weeks will afford factual data upon which intelligent flood control can be based.

Oil-water separation. Special water knockouts may be required ahead of the gun barrel to assist in handling highly water-cut fluids. Inclined vessels with baffles and drainage arrangements can be fabricated inexpensively on the lease for this purpose. For some crudes, the installation of heater-treaters will represent a significant investment.

Inhibitors. Provision for the lubrication of corrosion inhibitors and emulsion breakers into the producing wells should be reviewed in planning the well equipment installation.

Part 7 of this series will deal with the source and treatment of flood water. Included will be discussions on treating problems, the open versus the closed system, and other important considerations in providing a suitable flood water.

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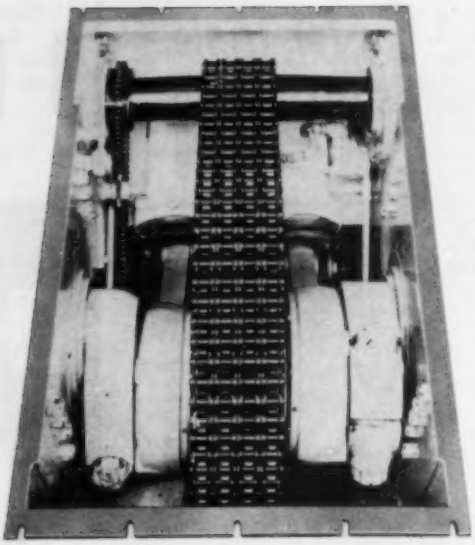


QUADRUPLE ROLLER CHAIN DRIVE has accounted for reduced weight and made possible use of a true crank. All bearings are pressure lubricated.

100 strokes per minute possible with flooded suction

A new 510-hp mud pump that weighs 18,000 lb with valves, pistons, rods and liners included, is capable of operating at 100 strokes per minute with flooded suction. Designed and constructed by Wilson Manufacturing Company of Wichita Falls, Texas, this pump utilizes a roller-chain drive to achieve light weight. At rated capacity, this chain drive has a safety factor of 8 to 1.

A device called the suction flow equalizer accounts for the high speeds possible. With an 8-in. suction line 30 ft long and a 4-ft suction lift, the pump discharges 825 gpm at 750 psi with 7½-in. liners at a speed of 80 spm. At this speed, the pump has a continuous rating of 425 hp. Discharge pressure may go to 900 psi for 20 per cent of the time, at which speed, 510 input horsepower are required. With 6-in. liners and at a speed of 80 spm, pump output at 95 per cent volumetric efficiency will be 500 gpm at 1200 psi, or a maximum rating of 1400 psi for 20 per cent of running time. This volume will result in an annular velocity of 220 fpm in an 8¾-in. hole with 4½-in. drill pipe.

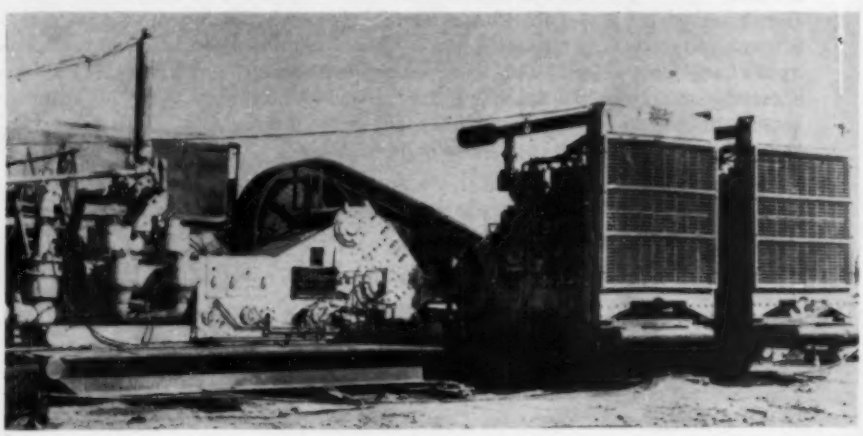
The suction flow equalizer aids getting the mud into the pump at high speeds. In an actual test without this device, the pump pounded badly at only 54 spm when pumping 9-lb mud from an 8-in. suction line 30 ft long and with a 4-ft suction lift. An indicator card on the suction showed pressure varied from 8 psi below atmospheric to 24 psi above.

Under the same conditions with the flow equalizer device, the pump was run as high as 75 spm without pounding against 650-psi discharge pressure. Liners in both tests were 7½-in. An indicator card taken on the suction side showed a pressure variation of only 2 psi, from 1 psi below atmospheric to 3 psi below atmospheric.

Liners Pumped Out. Cylinder liners are equipped with standard packing including a weep ring and heavy, single bolt-engaged retainer. They are also equipped with two "O"-ring grooves at each end to keep out sand from behind the liner. These "O"-rings also make it possible to pump the liner out with hydraulic pressure. The cylinder heads, as well as the valve covers are designed for quick and easy removal.

Unique Packing Gland. The rod packing gland has a 4-thread, Acme-type thread to tighten the gland, with gear teeth cut in the outside diameter of this nut. These teeth mesh with a pinion on one of the cylinder head studs. The stuffing box is tightened by placing a ratchet wrench around the nut and rocking back and forth.

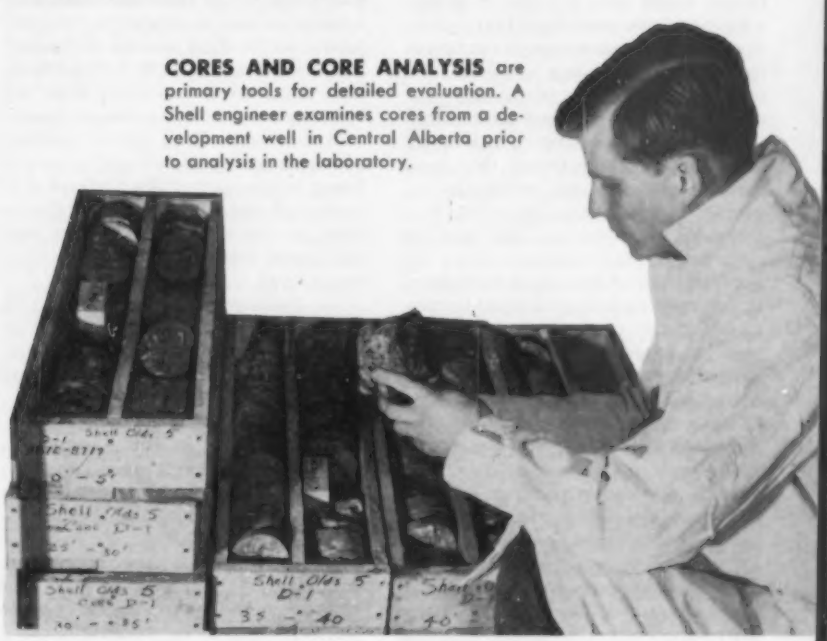
Maximum liner size is 7½ in. with a 14-in. stroke. This new idea in mud pumps is the result of some 15 years of design, engineering and field testing. ★



NEW PUMP ON LOCATION in West Texas undergoing extensive testing. Actual size is shown by comparison with two engines driving the pump.

Planning a Logging Program

Some practical tips to provide the data you need at minimum cost through careful planning



CORES AND CORE ANALYSIS are primary tools for detailed evaluation. A Shell engineer examines cores from a development well in Central Alberta prior to analysis in the laboratory.

A. G. T. Weaver
Logging Engineer,
Shell Oil Co., Calgary Area

BEFORE a logging program can be efficiently designed, a clear definition of the problem to be met and a thorough understanding of the available tools are vitally necessary. Detailed studies and experiences of past logging performance in an area then raise the reliability of evaluations up to those set by the limitations of the tools. These limitations can be largely offset by achieving balance in the tools chosen for a job.

Success of evaluation planning is measured by the soundness of the resulting interpretations and by evaluation costs. Any planning of a program that will reduce costs and provide adequate information has served its purpose.

The term "logging" covers all methods and tools used to evaluate the nature of reservoir rocks and their content. The application of logging fits comfortably between geology, concerned mainly with structure, stratigraphy, etc., and reservoir engineering, which deals primarily with the behavior of fluids in the reservoir. The science of log intrepretation covers the large span between these branches and overlaps to a large extent.

Object in planning. Stated simply, the object of planning a logging program is to obtain an adequate amount of information on subsurface formations as economically as possible. The amount of information that may be described as "adequate" will vary considerably with individual cases, and those responsible for the evaluation of a well first must be quite clear about what information is required. In working out the economics of a program, the intangible factors such as the possible hazards that may be involved in obtaining the information should be considered.

Another very important point to be considered in planning a program is the various groups of people who must use the results obtained from it. Obviously, every employee of an oil company is affected by the success (or otherwise) of evaluating techniques. More directly concerned are technical personnel who must make a recommendation based on the results, and management, which has to deal with the recommendations. Since geologists and engineers who plan the methods of evaluation are usually the men who also work out the data, their main concern is to follow the program through to the end and to have confidence, in the final outcome, that their evaluation is technically sound. If any doubt exists, further information must be obtained. Having confidence in their tools is one of the main requisites for the job.

In a similar manner, management must develop confidence in its logging personnel. In order to achieve this, not only must management be informed of the expense that can be saved by the application of a certain logging program, but probably more important, it must have the assurance that the limitations of the various logging tools are fully understood and that the program contains adequate provision to allow for these limitations. This applies particularly in the case of wildcats, where it would be false economy if a cheap evaluation program would lead to faulty interpretations. On the other hand, over-evaluation and needless expenditure is also to be avoided. Management will be happy when an intelligent method is adopted to obtain adequate information without unnecessary cost.

Logging tools available. Before dis-

cussing how this may be achieved, it will be worthwhile to mention briefly a few salient points concerning various logging tools available today.

1. *Drillers Log.* Early in the life of the oil industry, this was the only log available and has been superseded by more scientific devices. It is well to remember, however, that wellsite personnel even today may pick up some useful information from the driller about the formation being drilled.

2. *Ditch Samples.* This may be included in the general term "mud logging" and is the most important evaluation tool. It is no exaggeration to say that all other logging tools are virtually useless without lithological control, which can be obtained continuously from proper samples. It is essential, especially in wildcats, that good samples are obtained, efficiently examined and accurately described. Furthermore, it is important that they are described in the first instance from the point of view of formation evaluation, that is, to include all information necessary for the interpretation of other logs. Stratigrapher's descriptions of samples are sometimes not suitable for evaluation work, especially in the case of carbonates, where the prime consideration is the nature and size of void space both in the matrix and in the form of secondary porosity (ref. Archie Classification). The description of "shows" in samples is also important but should be used with caution as they can sometimes be misleading.

3. *Cores and Core Analyses.* These are primary tools for use when detailed evaluation is required and can be obtained by conventional wireline or sidewall methods. All these methods produce samples capable of analysis. It is a good maxim to remember that if a core is worth taking, it is also worth analyzing. Analysis of cores should include measurements of porosity, permeabliity, fluid saturations, salinity, capillary pressures and formation factors. Extra measurements such as solubilities (of carbonates), clay content and relative permeabilities should also be made when possible.

4. *Drillstem Test.* This is a potent logging tool and can often give very conclusive results concerning the fluid content of a permeable zone. Like all other logging tools, however, it is by no means infallible. In the first place, it is not always possible to know where to test in order to obtain the best information, although the increasing use of straddle and selective-zone testers will tend to overcome this disadvantage. Inconclusive results may also be small, for it is possible that lack of recovery is due to blockage of the formation around the bore-hole (skin effect) rather than to the naturally low permeability of the zone.

Quantitative analyses of the pressure chart can often help to solve this problem providing that sufficient pressure build-up time is allowed and pressures are accurately recorded. In this way, it is possible, in many cases, to estimate formation permeability and also skin effect, which can be removed by stimulating techniques. It is believed that more attention should be paid to this aspect of drillstem testing.

It should also be pointed out that sometimes actual fluid recoveries can sometimes lead to erroneous interpretations of the fluid content of the formation. For example, it is possible to have small water recoveries from the tighter portions of an oil-water transition zone and still be able to produce oil from better developed reservoir lower in the section. The inference is that small water recoveries in drillstem tests do not necessarily indicate that the tested interval is below the free water level.

5. *Drilling-time Logs.* This can be very useful to the wellsite engineer or geologist in locating changes in lithology and in the selecting of coring and testing points.

6. *Electric logs.* The original purpose for which electric logging was used, i.e., to obtain a quantitative picture of changes of rock type in the vertical section, still is important today. To some degree, all electric logs (together with sample descriptions) are lithology logs, but also we now have the very important application of quantitative electrical measurements.

Accurate estimations of reservoir data from electrical measurements start with a good knowledge of (a) formation lithology, obtained in most cases from samples; (b) formation water resistivity (or salinity) derived from actual measurements in the area or in many cases from the spontaneous potential curve, and (c) nature and properties of the drilling fluid used in the well. How closely these items are known, can be obtained or are subject to control (in the case of mud) will considerably affect the choice of logs used to evaluate a well.

With this background of information available, use of electrical measurements is made purely by substitution in the following basic formulas:

$$F = \frac{R_o}{R_w} = F^m \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$I = \frac{R_t}{R_o} = S^n \quad . \quad . \quad . \quad . \quad . \quad (2)$$

All other formulas used in electric logging are based on these.

It is, therefore, seen that the two essential items of information required from electric logs are formation resistivity factor (or porosity as it can usually be obtained from lithological considerations together with laboratory measurements) and true formation resistivity (R_t). It follows that electric logs fall into two groups according to which type of quantitative data they aim to supply.

(a) *Logs Measuring R_t.* These include normal resistivity curves, inverse resistivity curves, focussed device logs and induction logs, all of which have their own specific application according to the local conditions. It is seldom that any of these devices measure R_t directly and corrections must be made for bore hole, invasion, reservoir geometry, etc. There are also some cases where R_t cannot be evaluated and other tools must be used to obtain the necessary reservoir data.

(b) *Logs Measuring Formation Factor.* Included in this group are the pad resistivity devices, both focussed and unfocussed; the limestone device and sometimes a short normal. All of these tools make use of the invaded zone resistivity to supply the required information, and this means that a good understanding of conditions in the invaded zone must be on hand before reliable data can be derived. This includes mud filtrate resistivity, quantities of residual formation water and hydrocarbon, mud cake thickness, etc., all of which may vary according to the nature of the invaded formation.

The descriptive data which such logs can provide also must guide the choice of logs to be run.

7. *Radioactive Logs.* As in the case of electric logging, the qualitative use of radioactive logs has also now been augmented by their quantitative application. This applies particularly in the case of the neutron log from which, with sufficient control, a reasonable value of porosity can be obtained, especially in carbonate rocks. The gamma ray log is still essentially a useful lithology log. It is worthy of mention that the technicalities behind radioactivity logging are very involved, and, hence, their quantitative application is necessarily empirical. Since also the use of empirical data is dependent on good calibration of the logging tool, it is imperative that the log interpreter must be closely familiar with the instrumentation problems met in this type of logging and to have some means of checking the calibration of the log. If such a check is not available, the log must be restricted to descriptive and comparative use only.

8. *Other Logs.* There are many direct logging tools such as deviation measurements, the dipmeter and temperature logs that may have an application in evaluation work. There have been several cases in which a bit record has been used to good effect. All logs

of this type should be considered in the final analysis.

Choosing logs to run. It is apparent that most evaluation tools at our disposal suffer from some limitation. In deciding which to use for a specific job, the assortment of logs chosen should as far as possible cover up the weaknesses of each other according to the conditions to be met.

The first thing to do, however, is to define the problem, that is, to understand fully what information is required. The evaluation problem may be divided into three types, those encountered in (1) wildcatting, (2) field development drilling and (3) continuous stratigraphic testing. These cover both exploration and production activities and are closely interrelated.

1. *Wildcat Evaluation.* Under this heading the problem may be defined in three parts:

(a) Identification of possible reservoir zones.

(b) Establish the fluid content of those zones.

(c) If hydrocarbon bearing, to estimate the economic possibilties for completion.

Since the primary object of wildcat operations is to *find* oil or gas, the first two points are the most important although the third, which involves a rough esimate of hydrocarbon in place and the extent to which it may be produced, is a necessary supernumerary. This philosophy will influence the design of a logging program.

Another important point concerning wildcats is that, by their very nature, they do not lend themselves to close control with respect to the nature of the formations to be penetrated or of the mechanical conditions that may affect our logs. For this reason, use of the more complicated logging tools should be avoided and the evaluation program should be as simple as possible.

Probably the simplest tool of all is *sample analysis*, and this provides the fundamental basis for application of all other tools to be used. It cannot be emphasized too strongly that good samples are essential, for they not only provide clues to reservoir characteristics but also to the parameters to be used in electrical evaluation.

When wellsite examination of samples indicates the bit has entered a possibly hydrocarbon-bearing permeable formation, this should be confirmed by a *drillstem test*, making sure that sufficient closed-in time is allowed for best use of the pressure chart (usually one hour open and one hour shut). Generally speaking, in wildcats it is more economical to test on the way down than after reaching total depth.

At pre-arranged intervals depending on local conditions (not greater than 60 days), the electric logs should be run. Purpose is to evaluate further tested zones and, more important, to locate possible reservoirs not tested or picked up by samples. For this purpose, logs should be run over the entire penetrated interval. Probably the best electric logs for a wildcat are the normal electric log and the microlog or contact log. The first is the best all-round source of electrical data and the second, while mainly useful in providing descriptive data, is also of value as a source of limited quantitative information. In cases where the use of electric logs leaves the evaluation of a sand in doubt, often the matter can be settled by means of percussion-type sidewall samples, which can be given close visual examination or be analyzed in the laboratory. In cases of continued doubt, a straddle test of the zone should be made.

On reaching total depth, further useful information can be obtained, especially in limestone formations, by running a radioactive log. In wildcats, quantitative data obtained from this log should be used with discretion and preferably on a comparative basis.

Several tools have not been mentioned for evaluation use in wildcats. This includes conventional and wireline cores, which are considered more suitable for detailed analysis after the reservoir has been found. Also, it is considered that supplementary electric logs such as the laterolog, microlaterolog and induction log have their application limited to specific conditions and at present are not general wildcatting tools.

2. *Development Well Evaluation.* Development wells are drilled after the reservoir has been found by the wildcat, i.e., the reservoir has been identified and the fluid content established. The logging problem met in this type of well, therefore, may be defined as:

(a) Estimation of the amount of oil (or gas) in place.

(b) Determination of the distribution of the oil in the reservoir with respect to rock porosity, permeability, water content and the reservoir geometry.

Item (2) is to help in the estimation of how much of the oil is producible, the numerical order of recovery efficiency and to provide a clue to the magnitude of water cuts that may be expected during production life. These studies also assist in planning any remedial work that may become necessary.

In order to determine the best logging method for production wells, a period of appraisal is necessary in the early life of the field. During this period, several wells should be cored completely through the pay section and complete analysis made, including capillary pressure and formation factor measurements. Cored wells also should be logged with other tools that appear to have possibilities of providing the required data. Studies must then be made to determine the best and most economical logs for the job and the best mechanical conditions in which to run them.

Eventually the evaluation problem will often resolve itself into the measurement of one or two important reservoir properties from which the others will easily follow. In some fields, the prime considerations may be the amount of lithogical types, as in Pembina and Virden, or water content variations due to changing capillary effects, as in southeast Saskatchewan, or porosity and its distribution within the vertical section, as in the Alberta reef reservoirs. These properties can be deduced from core analysis and drillstem tests, but since these are expensive operations, it is desirable to be able to determine them from electric and radioactive logs. The appraisal period is complete when core and drillstem test data can be matched with reasonable accuracy with other logs and routine coring and testing are no longer necessary.

Following the appraisal period, it should be possible to reduce considerably the evaluation costs in a field. Unnecessary logs may be discarded, and this is where the electric log and microlog often lose favor to the more specialized logs such as the focused devices, induction log, etc. Wells should be cored periodically to continually check the logging method and to allow for experimentation that may lead to improvement in the technique. All of this phase should, of course, be discussed with drilling personnel with whom control of mud properties must be arranged.

The Author

A. G. T. Weaver is presently logging engineer for Shell Oil Company's Calgary area at Calgary, Alberta, Canada. A graduate of the University of Birmingham, England, in petroleum engineering, he served after graduation in 1942, for five years in the British Army, in India and Burma. He joined Shell in 1947 and has worked in The Hague, South America, the United States and Canada.

...One

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PERMANENT-TYPE WELL COMPLETIONS

RETAINER PRODUCTION PACKER

PRODUCT NO. 415-D

The Baker Retainer Production Packer has been used in nearly every production application, old or new, and promises to play an even greater role in future production applications.

Because it can also be used successfully as a squeeze tool, it is used in a variety of supplemental applications (such as testing, acidizing, formation fracturing, squeeze cementing, etc.) that might be required during the completion or work-over phase of a well. That is why the Baker Retainer Production Packer has been frequently referred to as the "universal" packer, because it is truly the *one* packer that can be used *for all* production and many supplemental applications.

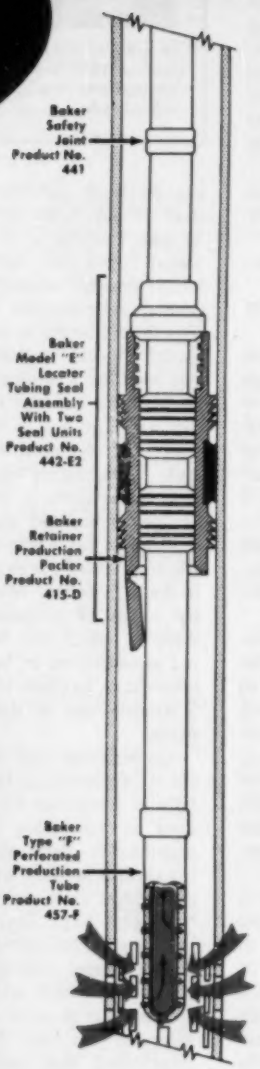
FEATURES

Can be run and set with the speed and accuracy of wire line, as well as on tubing or drill pipe.

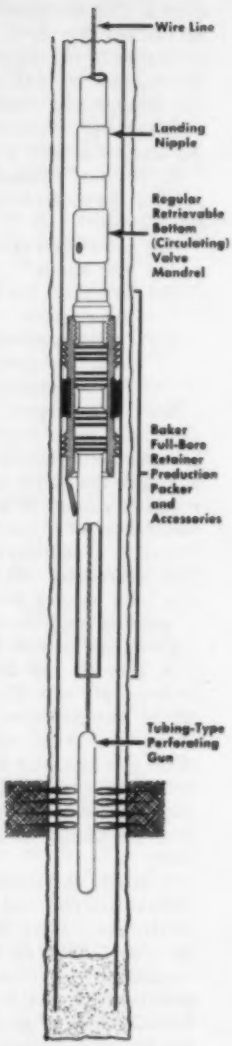
Holds any pressure from either above or below that is safe for the casing, even under temperatures in excess of 300°F.

Pack-off is independent of set-down weight or tension. Tubing string is free; just pick up (or unlatch and pick up) to remove it.

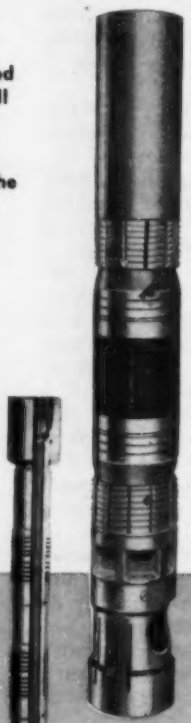
When tubing is removed, flapper valve closes to isolate zone below packer.


Baker Safety Joint Product No. 441
Baker Model "E" Locator Tubing Seal Assembly With Two Seal Units Product No. 442-E2
Baker Retainer Production Packer Product No. 415-D
Baker Type "P" Perforated Production Tube Product No. 457-P

Illustrates Packer set in casing with Locator Tubing Seal Assembly and Production Tube installed for single zone production.


Wire Line
Landing Nipple
Regular Retrievable Bottom (Circulating) Valve Mandrel
Baker Full-Bore Retainer Production Packer and Accessories
Tubing-Type Perforating Gun

Illustrates typical Permanent-Type Well Completion Hook-Up showing perforating operation through and below the Packer.



Baker Locator Tubing Seal Assembly Product No. 442-E2

Baker Retainer Production Packer Product No. 415-D

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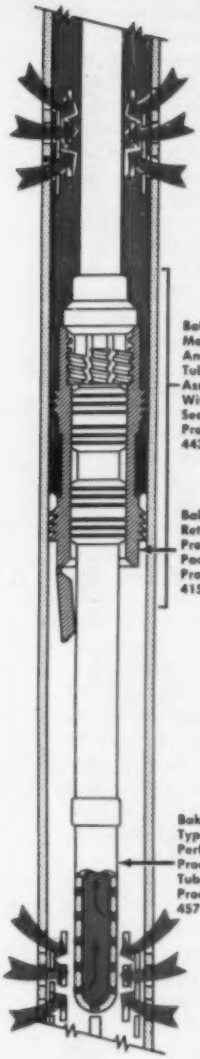
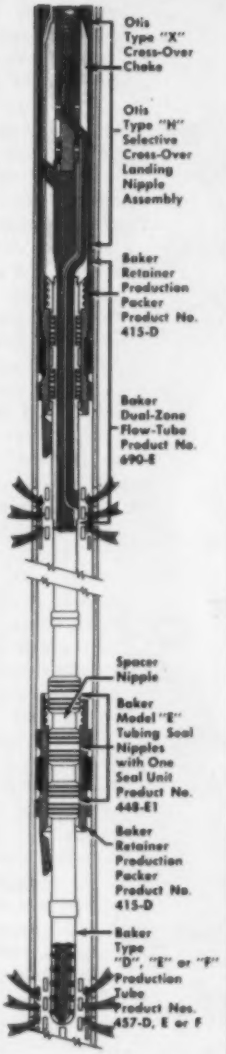
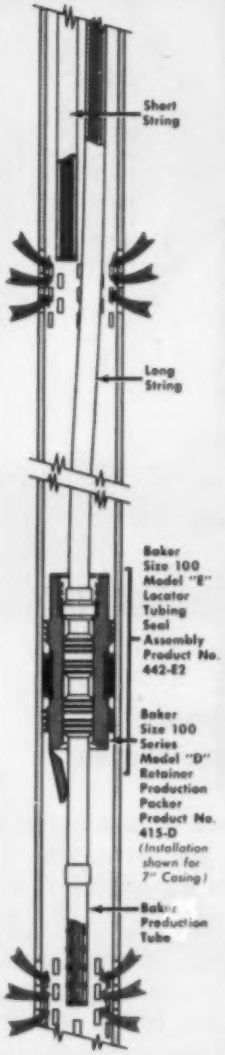

Baker Model "E" Anchor Tubing Seal Assembly With Two Seal Units Product No. 443-E2
Baker Retainer Production Packer Product No. 415-D
Baker Type "F" Perforated Production Tube Product No. 457-F

Illustrates Packer set in casing, with anchored production string for dual zone production. Tubing can be released from packer by rotating to right.


Otis Type "X" Cross-Over Choke
Otis Type "H" Selective Cross-Over Landing Nipple Assembly
Baker Retainer Production Packer Product No. 415-D
Baker Dual-Zone Flow-Tube Product No. 690-E
Spacer Nipple
Baker Model "E" Tubing Seal Nipples with One Seal Unit Product No. 448-E1
Baker Retainer Production Packer Product No. 415-D
Baker Type "D", "E" or "F" Production Tube Product Nos. 457-D, E or F

Illustrates selective two packer dual zone production hook-up (Baker-Otis) with Cross-over Choke installed. Flow pattern can be switched with Parallel Flow Choke.


Short String
Long String
Baker Size 100 Model "E" Locator Tubing Seal Assembly Product No. 442-E2
Baker Size 100 Series Model "D" Retainer Production Packer Product No. 415-D (Installation shown for 7" Casing)
Baker Production Tube

Illustrates simplest type of parallel string installation. Other installations involving two packers with full-opening tubing running through and below lower packer available.

WATER OR GAS INJECTION

The Baker Retainer Production Packer contains features that permit it to be used as a squeeze or testing tool as well as a temporary or permanent bridge plug. It is thus used in a variety of supplemental applications such as gas or water injection, testing, fracturing, acidizing, etc., that may be required either during the completion phase of a well or during a later phase.

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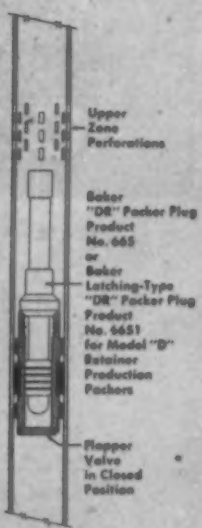
Upper Zone Perforations
Baker "DR" Packer Plug Product No. 665 or Baker Latching-Type "DR" Packer Plug Product No. 6651 for Model "D" Retainer Production Packers
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By following a program in this manner, reasonable, effective evaluation technique can be developed for any new field.

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Clearly no program of this type can be carried out without good logging control previously established and an experienced logging man directly in charge of evaluation operations. Also, the essence of speed is lost for depths much greater than 5000 ft.

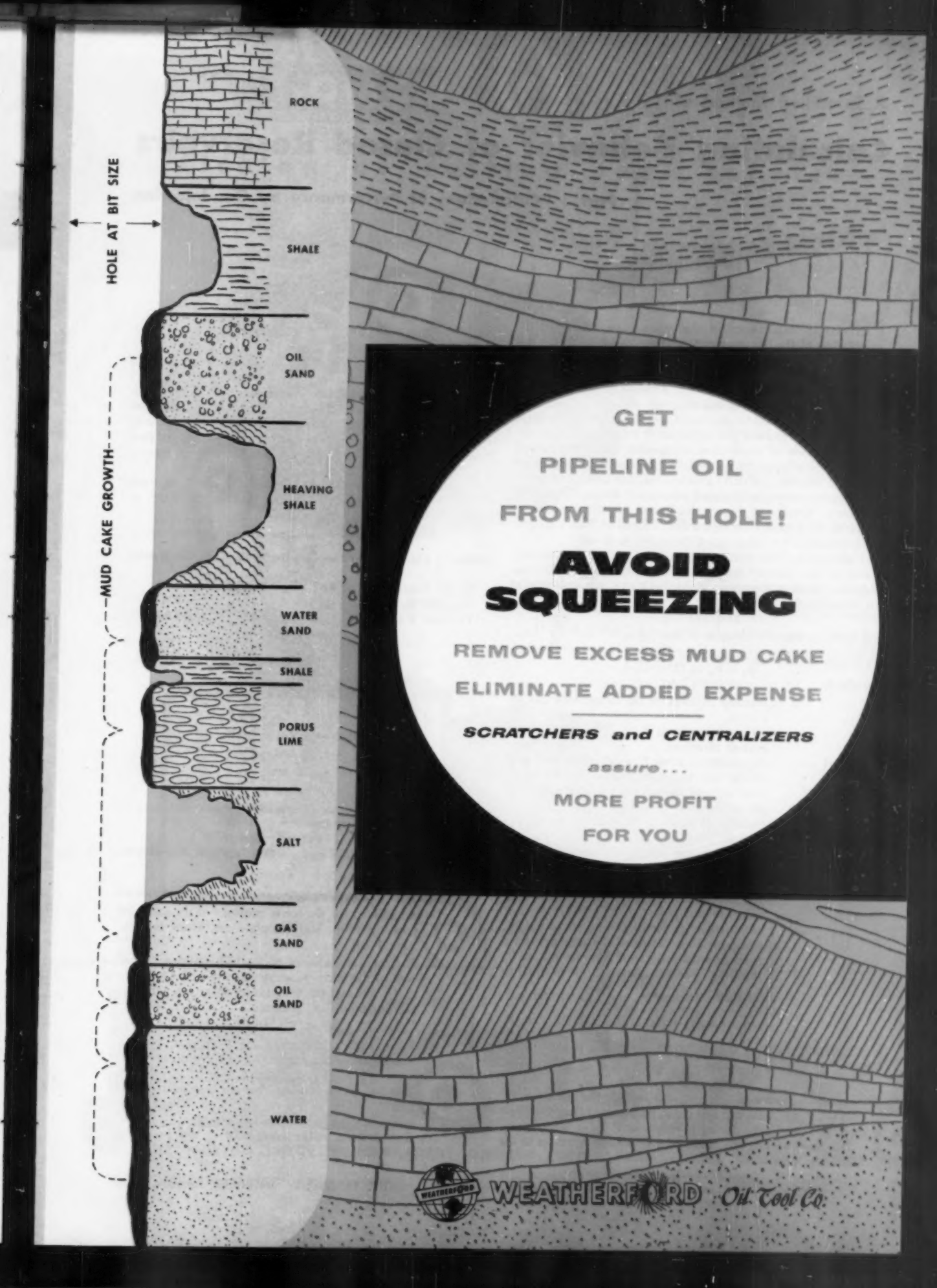
A logging program for this type of well is based on experience in the area. Sample analysis is again the most important tool, and special provision must be made to insure that adequate samples are collected. A continuous strip log showing lithology, oil and gas shows and drilling speed should be currently maintained by the wellsite engineer (or geologist). Mud properties should be maintained to those most suitable for interpretation of the previously chosen electric and radioactive logs that are run at total depth.

At this point, the wellsite evaluation of the well is made. When, after this evaluation, there remain reservoir formations that cannot be proved to be water-bearing or otherwise uncommercial, further tests in the form of sidewall cores (percussion-type) or a selective zone drillstem test may be necessary. In cases where the final evaluation indicates a zone of commercial significance, the drilling rig should move to the next prepared location immediately after setting pipe. Production testing of the zone then would be carried out later by a work-over rig.

Acknowledgment

This article is based upon a paper presented by the author before the October, 1955, meeting of the Canadian Society for Well Log Interpretation.

★ ★ ★


ROCK
HOLE AT BIT SIZE
SHALE
OIL SAND
MUD CAKE GROWTH
HEAVING SHALE
WATER SAND
SHALE
POROUS LIME
SALT
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Calculating Behavior of Closed Reservoirs

Part 3 Calculations of Performance by Gas Injection

W. C. Sturdivant, Jr.
Sun Oil Company,
Dallas, Texas

PREVIOUS installments of this series have illustrated the calculation of the behavior of Reservoir "X" by solution gas drive. Part 3, last in this series, demonstrates how to calculate the performance of Reservoir "X" by gas injection.

In any gas injection operation in a closed reservoir, it must be presumed that part of the reservoir will not be swept by injected gas, and will be produced only by solution gas drive (or by solution gas and gas cap drive, if a gas cap is present). The calculation of production increments from that part of the reservoir affected by gas injection is done in the same way as in the solution gas drive case except that altered forms of the saturation and incremental volumetric balance equations are used. Results of these calculations are combined with those of the pressure depletion calculations of Part 2 to give an estimate of the behavior of the entire reservoir.

Calculation of the performance of that part of the reservoir swept by gas includes use of the following equation (derivation presented in the appendix of this part), which is similar to Equation 4.

$$\text{(Eq. 5a)}\quad \Delta n_e = \frac{1.0-[n_{t-1}+\Delta n_p(1-e)]\phi_g-[g_m+(g_{t-1}+\Delta g_p[1-e])(1-I\frac{Z'}{Z})]\phi_g}{\phi_n + r_{ae}\,\phi_g\,[1-I\frac{Z'}{Z}]}$$

in which:

e = fraction of in-place oil affected by gas injection.

Δn_e = oil produced from P_1 to P_2 from gas-swept part of reservoir.

$\Delta n_p(1-e)$ = oil produced from P_1 to P_2 from that part of the reservoir not affected by gas injection, and $\Delta g_p(1-e)$ is the corresponding gas production.

e = fraction of in-place oil affected by gas injection.

g_m = cumulative gas produced before gas injection began.

I = fraction of gas produced since beginning of gas injection, which has been returned to reservoir at P_2.

Z' = compressibility factor of injected gas at P_2.

Z = compressibility factor of liberated gas at P_2.

r_{ae} = average produced gas-oil ratio from P_1 to P_2 resulting from gas injection, and is equal to $\frac{r_{ie}+r_{ie-1}}{2}$, where r_{ie} and r_{ie-1} are the corresponding instantaneous GOR's at P_1 and P_2.

n_{t-1} = cumulative oil production to P_1.

g_{t-1} = cumulative gas production to P_1 after beginning of gas injection.

ϕ_n and ϕ_g correspond to P_2, and include the gas cap term only if there is a gas cap and it can be assumed that it diffuses through the oil zone during production.

It is also necessary to modify the saturation equation to the following form:

$$\text{(Eq. 6b)}\quad S_{oe} = [e-n_e]\,B\,[\frac{1-S_w}{e\,B_o}]$$

In which:

S_{oe} = Saturation of oil in gas injection-affected part of reservoir.

Example 3—Gas Injection Performance. Problem: Calculate the performance of Reservoir "X" under gas injection from 1930 psi bottom-hole pressure, assuming 70 per cent of the reservoir will be swept by injected gas, 75 per cent of produced gas will be returned, and the injected gas will have a specific gravity of 0.62.

Given: Data and solution of Examples 1 and 2 in Parts 1 (November, 1955, p. B-95) and 2 (December, 1955, p. B-105) of this series.

TABLE 7. Calculation of $1-\frac{Z'}{Z}I$ for 75 Per Cent Gas Return.

Sp. Gr. Injected Gas = 0.62 **T_R = 1.65**
T_c = 363°R. **P_c = 671**
T_o = 140°F = 600°R. **I = 0.75**

1	2	3	4	5	6	7
P	P_R	Z'	Z	$\frac{Z'}{Z}$	$\frac{Z'}{Z}I$	$1-\frac{Z'}{Z}I$
psia	Inj. gas	Inj. gas	Lib. gas			
1915	2.85	.849	.765	1.110	.832	.168
1715	2.56	.855	.788	1.085	.814	.186
1515	2.26	.868	.805	1.078	.809	.191
1315	1.96	.880	.820	1.073	.805	.195
1115	1.66	.895	.840	1.065	.799	.201
915	1.36	.910	.855	1.064	.798	.202
715	1.07	.929	.872	1.065	.799	.201
515	.77	.949	.890	1.066	.800	.200
315	.47	.968	.905	1.070	.803	.197
14.65	—	1.0	1.0	1.0	.75	.25
	▲ P/Pc	▲ From Fig. 3	▲ From Table 1			

Solution:

a. Calculate the term $1-I\frac{Z'}{Z}$ as a function of pressure, as shown in Table 7.

b. Calculate performance as shown in Table 8, as follows:

[1] Assume r_{ie} for the lower pressure of the assumed pressure drop, and calculate Δn_e from Eq. 5a. [Col. 1-20].

[2] For the first value of n_e [at 1930 lb] use 70 per cent of the corresponding value in Col. 12, Table 6. To this add the summation of Δn_e to get n_e at the corresponding pressure.

[3] Calculate S_{oe} from Eq. 6b [Col. 21-25].

[4] From Fig. 9, determine the k_g/k_o for the gas-swept part of the reservoir as a function of S_{oe}.

[5] Calculate r_{ie} [Eq. 7a] as indicated by Col. 27-30. If the r_{ie} value of Col. 30 is not very near that of Col. 2, assume a new value for Col. 2, equal to or near the calculated value in Col. 30.

[6] Calculate r_{ae} as the average of r_{ie} and preceding r_{ie} of Col. 30.

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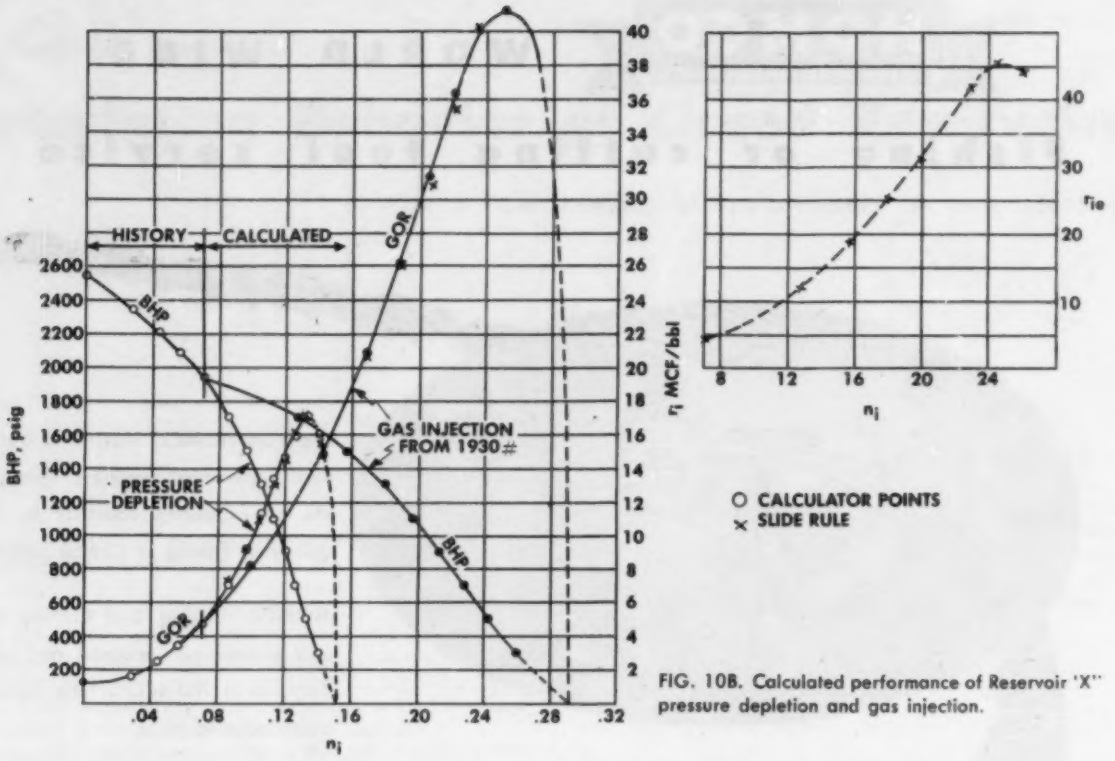

FIG. 10B. Calculated performance of Reservoir "X" pressure depletion and gas injection.

[7] Calculate Δg_e, and cumulate to get g_i of Col. 34. [It should be noted that g_i is the cumulative gas produced from the gas injection-affected part of the reservoir since beginning of gas injection only.]

[8] Col. 35 and 36 complete the calculation of the multiplier of ϕ_g in the last term in the numerator of Eq. 5a, noted by the term $\bar{g}$. This is the same as the term g in Eq. 1 and is used as such in checking the balance [Col. 39-41].

[9] Col. 37 and 38 cummulate the total oil production [n_i] and Col. 39-41 complete the balance. [N of Col. 41 must be near 1.0].

[10] In order to plot the overall reservoir performance [combination of pressure depletion and gas injection mechanisms], it is necessary to calculate the average GOR during a production increment [Col. 42] and the corresponding cumulative production at the mid-point of the increment. [Col. 43]. These are the values plotted in Fig. 10B.

In making first estimates of r_{ie}, it is useful to plot r_{ie} as a function of n_i and extrapolate to the n_i value indicated by the n_i versus BHP curve. Such a plot is shown in the upper right-hand corner of Fig. 10B.

As in Example 2, it was found that a slide rule calculation of Table 8 gave satisfactory accuracy.

The saturation equation (6b) assumes that all injected gas is uniformly distributed throughout the gas injection-affected part of the reservoir. This assumption is approximately correct only after injected gas breakthrough has occurred. Consequently, these gas injection calculations are not an acceptable means of estimating gas-oil ratio behavior except after gas breakthrough. They do, however, give a method of estimating the additional oil recovery to be obtained by conserving reservoir pressure.

Appendix

Derivation of Equation 5a. In the volumetric balance equation, which may be written:

$$N = \frac{n\,(B - r_s v) + gv}{(B - r_s v) - (B_o - r_o v) + m\,B_o\,(\frac{v''}{v_o''} - 1)}$$

the term gv is the volume which the produced gas would occupy at reservoir conditions. If gas is injected, this term must be corrected by the volume occupied by injected gas, and becomes $(gv - g'v')$.

However, for any pressure and temperature,

$$\frac{v}{Z} = \frac{v'}{Z'} \text{ or, } v' = v\,\frac{Z'}{Z}$$

Then:

$$gv - g'v' = v\,(g - g'\,\frac{Z'}{Z}) = \bar{g}$$

and the volumetric balance equation may be written:

$$\text{(Eq. 1a)}\quad N = n\,\phi_n + \bar{g}\,\phi_g$$

Under gas injection operations, part of the reservoir will not be swept by injected gas, and each increment of production will be composed of oil and gas produced partially by pressure depletion, and partially by gas drive. Let "e" represent that fraction of the in-place oil in the gas-swept portion of the reservoir, and "1 — e" that fraction in the portion of the reservoir produced by pressure depletion.

Let:

Δn_e = Increment of oil produced by gas injection, and
Δg_e = Corresponding increment of gas production.
Δn_p = Increment of oil which would be produced if no gas were injected, and
Δg_p = Corresponding increment of gas.
I = Fraction of produced gas returned to the reservoir.

Then:

$$\Delta n = \Delta n_p\,(1 - e) + \Delta n_e$$
$$n = n_{i-1} + \Delta n_p\,(1 - e) + \Delta n_e$$
$$\Delta g = \Delta g_p\,(1 - e) + \Delta g_e =$$
$$\Delta g_p\,(1 - e) + \Delta n_e\,\frac{r_{ie} + r_{ie-1}}{2}$$
$$= \Delta g_p\,(1 - e) + \Delta n_e\,r_{ae}$$

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TABLE 8. Calculation of Performance by 75 Per Cent Gas Return From 1930 psi Bhp.

$e = .70$ $\quad 1 - e = .30$ $\quad I = .75$ $\quad S_w = .20$ $\quad B_o = 1.652$ $\quad \frac{(1-S_w)}{eB_o} = .6920$ $\quad g_m = 3557$ MMCF/22.2 MM Bbl $= .1602$

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
P	r_{te}	r_{se}	ϕ_n	ϕ_g	Δn_p	$\Delta n_p(1-e)$	$\frac{n_{i-1}+}{\Delta n_p(1-e)}$	$(8)\times\phi_n$	Δg_p	$\Delta g_p(1-e)$	$\frac{g_{i-1}+}{\Delta g_p(1-e)}$	$1-I\frac{Z'}{Z}$	$(13)\times(12)$	$g_m+(14)$
1930	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1700	15.00	9.78	.54	3.79	.0158	.0047	.0789	.0410	.0913	.0274	.0274	.186	.0051	.1653
	11.20	7.88	—	—	—	—	—	—	—	—	—	—	—	—
	12.40	8.48	—	—	—	—	—	—	—	—	—	—	—	—
	12.00	8.28	—	—	—	—	—	—	—	—	—	—	—	—
	↓ Est. from plot of ni vs. rie													
1500	21.00	16.55	.18	2.91	.0107	.0032	.1313	.0236	.0862	.0259	.4876	.191	.0931	.2533
	19.00	15.55	—	—	—	—	—	—	—	—	—	—	—	—
1300	24.00	21.43	—.03	2.36	.0086	.0026	.1610	—.0048	.0881	.0264	.9335	.195	.1830	.3422
	25.50	22.18	—	—	—	—	—	—	—	—	—	—	—	—
1100	33.00	29.28	—.15	1.96	.0076	.0023	.1827	—.0274	.0938	.0281	1.3924	.201	.2799	.4401
	31.10	28.33	—	—	—	—	—	—	—	—	—	—	—	—
900	37.00	34.05	—.21	1.66	.0071	.0021	.1998	—.0420	.0993	.0298	1.8470	.202	.3731	.5333
700	43.00	39.87	—.24	1.43	.0067	.0020	.2158	—.0518	.1023	.0307	2.3525	.201	.4728	.6330
	41.70	39.22	—	—	—	—	—	—	—	—	—	—	—	—
500	42.00	41.67	—.23	1.24	.0067	.0020	.2310	—.0531	.1104	.0331	2.9071	.200	.5815	.7417
	45.60	43.67	—	—	—	—	—	—	—	—	—	—	—	—
300	40.00	42.84	—.21	1.08	.0074	.0022	.2458	—.0516	.1228	.0368	3.4951	.197	.6886	.8487
	44.20	44.94	—	—	—	—	—	—	—	—	—	—	—	—
▲ Same as in Table 6	▲ Assumed	▲ Avg. of Col. 2 Values	▲ From Fig. 5		▲ From Col. 11, Table 6				▲ From Col. 23, Table 6			▲ From Table 7		

1	16	17	18	19	20	21	22	23	24	25	26	27	28	29
P	$(15)\times\phi_g$	$1-(16)-(9)$	$\frac{r_{se}\times\phi_g}{\times(13)}$	$\phi_n+(18)$	$\frac{\Delta n_e}{(17)/(19)}$	n_e	$e-n_e$	B	$(e-n_e)B$	$\frac{S_{oe}}{(24)\times.692}$	k_g/k_o	F	F k_g/k_o	r_s MCF/Bbl
1930	—	—	—	—	(.0712)(.7)	.0498	—	—	—	—	—	—	—	—
1700	.6265	.3325	6.90	7.44	.0447	.0945	.6055	1.472	.8913	.617	.52	19.6	10.19	.92
	—	—	5.55	6.09	.0546	.1044	.5956	—	.8767	.607	.59	—	11.56	—
	—	—	5.98	6.52	.0510	.1008	.5992	—	.8820	.610	.56	—	10.98	—
	—	—	5.84	6.38	.0521	.1019	.5981	—	.8804	.609	.57	—	11.17	—
1500	.7371	.2393	9.20	9.38	.0255	.1275	.5725	1.433	.8204	.568	.96	18.4	17.66	.84
	—	—	8.64	8.82	.0271	.1290	.5810	—	.8181	.566	.98	—	18.03	—
1300	.8076	.1972	9.86	9.83	.0201	.1492	.5508	1.395	.7683	.532	1.45	17.1	24.80	.76
	—	—	10.21	10.18	.0194	.1485	.5515	—	.7693	.532	1.45	—	24.80	—
1100	.8626	.1648	11.54	11.39	.0145	.1630	.5370	1.360	.7303	.505	1.95	15.6	30.42	.68
	—	—	11.16	11.01	.0150	.1635	.5365	—	.7296	.505	1.95	—	30.42	—
900	.8853	.1547	11.42	11.21	.0140	.1775	.5225	1.325	.6923	.479	2.60	13.9	36.14	.60
700	.9052	.1466	11.46	11.25	.0130	.1905	.5095	1.290	.6573	.455	3.35	12.3	41.21	.52
	—	—	11.27	11.03	.0133	.1908	.5092	—	.6569	.455	3.35	—	41.21	—
500	.9197	.1334	10.38	10.15	.0131	.2039	.4961	1.250	.6231	.429	4.35	10.4	45.24	.43
	—	—	10.83	10.60	.0126	.2034	.4966	—	.6207	.429	4.35	—	45.24	—
300	.9166	.1359	9.12	8.91	.0152	.2186	.4814	1.235	.5801	.401	5.7	7.7	43.89	.33
	—	—	9.56	9.35	.0144	.2178	.4822	—	.5811	.402	5.7	—	43.89	—
								▲ From Fig. 2			▲ From Fig. 9	▲ From Fig. 8		▲ From Fig. 2

1	30	31	32	33	34	35	36	37	38	39	40	41	42	43
P	r_{te} MCF/ Bbl	r_{se} MCF/ Ebl	Δg_e $\Delta n_e\, r_{se}$ MCF	Δg_i (32)+(11) MCF	g_i $\Sigma\Delta g$ MCF	$g_i\times(13)$ MCF	$\bar{g}$ $g_m+(35)$ MCF	Δn (20)+(7)	n_i $\Sigma\Delta n$	$n_i\,\phi_n$	$\bar{g}\,\phi_g$	N	GOR $\Delta g/n$ MCF/Bbl	$\frac{n_{i-1}}{+\frac{\Delta n}{2}}$
1930	4.55	—	—	—	0	0	.1602	—	.0712	—	—	—	4.5	—
1700	11.11	—	—	—	—	—	—	—	—	—	—	—	—	—
	12.49	—	—	—	—	—	—	—	—	—	—	—	—	—
	11.99	—	—	—	—	—	—	—	—	—	—	—	—	—
	12.09	8.320	.4343	.4617	.4617	.0859	.2461	.0569	.1281	.0592	.9327	1.002	8.1	.010
1500	18.50	—	—	—	—	—	—	—	—	—	—	—	—	—
	18.87	15.48	.4195	.4454	.9071	.1732	.3334	.0303	.1584	.0285	.9702	.999	14.7	.143
1300	25.56	—	—	—	—	—	—	—	—	—	—	—	—	—
	25.56	22.21	.4309	.4573	1.3644	.2661	.4263	.0220	.1804	—.0054	1.0060	1.001	20.8	.169
1100	31.10	—	—	—	—	—	—	—	—	—	—	—	—	—
	31.10	28.33	.4250	.4531	1.8175	.3653	.5255	.0173	.1977	—.0297	1.0300	1.000	26.2	.189
900	36.74	33.92	.4749	.5047	2.3222	.4691	.6293	.0161	.2138	—.0449	1.0446	1.000	31.3	.206
700	41.73	—	—	—	—	—	—	—	—	—	—	—	—	—
	41.73	39.23	.5217	.5524	2.8746	.5778	.7380	.0153	.2291	—.0550	1.0553	1.000	36.3	.221
500	45.67	—	—	—	—	—	—	—	—	—	—	—	—	—
	45.67	43.70	.5506	.5837	3.4583	.6917	.8519	.0146	.2437	—.0560	1.0560	1.000	40.0	.236
300	44.22	—	—	—	—	—	—	—	—	—	—	—	—	—
	44.22	44.95	.6473	.6841	4.1424	.8161	.9763	.0166	.2603	—.0547	1.0544	1.000	41.2	.252
		▲ Avg. of Col. 30 Values												

(Where r_{ae} is the average gas-oil ratio of production from gas drive)

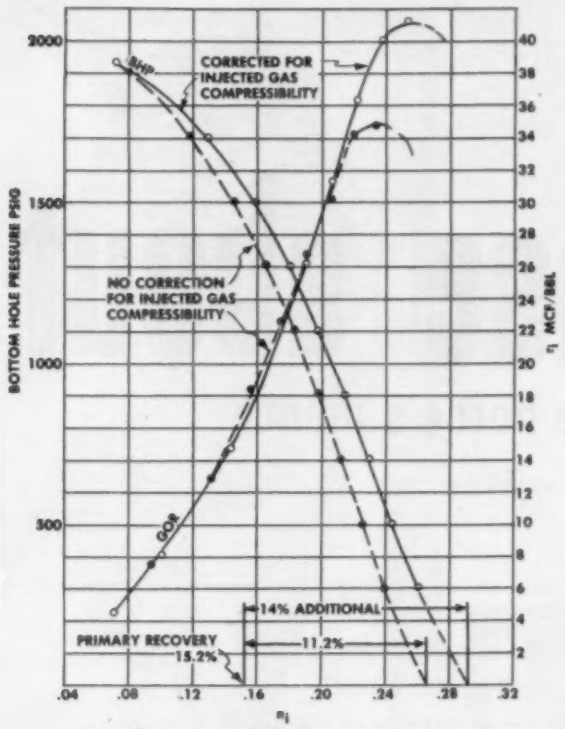


FIG. 10C. Performance of Reservoir "X" under gas injection with and without gas compressibility.

Let:

g_m = Cumulative gas produced before gas injection begins.

g_i = Cumulative gas produced from beginning of gas injection.

Then:

$$\bar{g} = g_m + g_i - g_i \frac{Z'}{Z} I = g_m + g_i (1 - I \frac{Z'}{Z})$$

Since:

$$g = g_{i-1} + \Delta g = g_{i-1} + \Delta g_p (1 - e) + \Delta n r_{ae}$$

Then:

$$\bar{g} = g_m + [g_{i-1} + \Delta g_p (1 - e) + \Delta n r_{ae}] [1 - I \frac{Z'}{Z}]$$

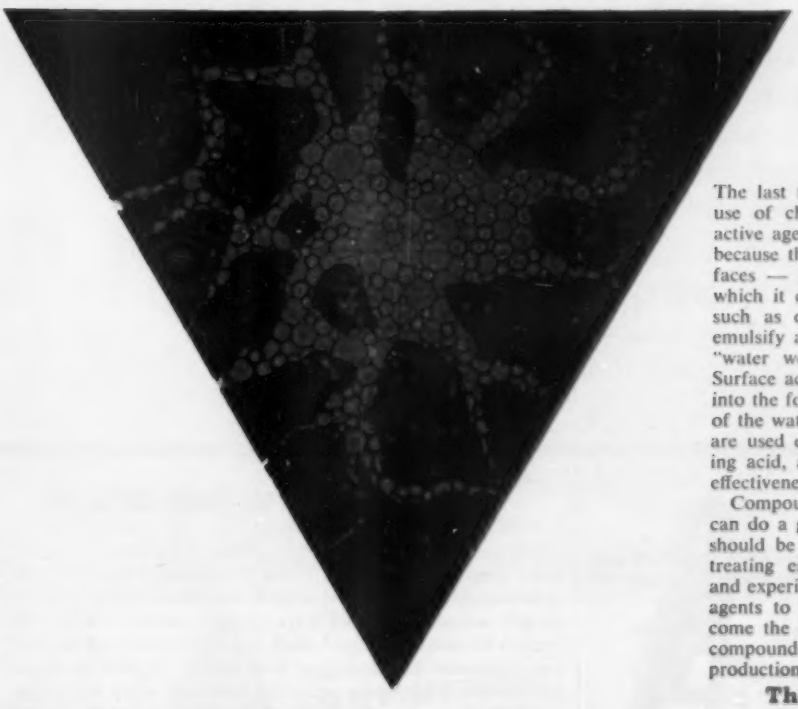
Substitute these values of n and $\bar{g}$ in Eq. 1a, set N = 1.0; expand; and solve for Δn_o:

$$\text{(Eq. 5a)} \quad \Delta n_o = \frac{1.0 - [n_{i-1} + \Delta n_p(1-e)]\phi_n - [g_m + (g_{i-1} + \Delta g_p[i-e])(1 - I\frac{Z'}{Z})]\phi_g}{\phi_n + r_{ae}\phi_g(1 - I\frac{Z'}{Z})}$$

Some doubt may be experienced as to the value of considering separately the compressibilities of injected and liberated gas. In order to determine the effect of neglecting this consideration, the calculations of Table 8 were repeated with $Z'/Z = 1.0$. Fig. 10C is a graph of the results of these calculations and the Table 8 calculations. It will be noted that, in the case of Reservoir "X," the estimate of additional oil to be recovered by gas injection would be reduced by 20 per cent if this gas compressibility correction were neglected.

Acknowledgment

The author wishes to thank the management of Sun Oil Company for permission to publish this series of articles. ★ ★



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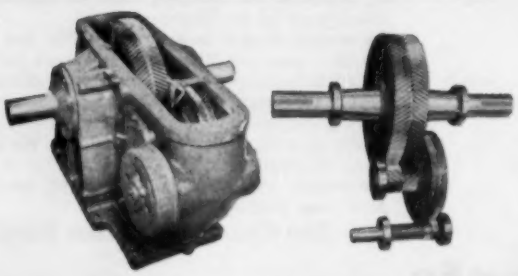

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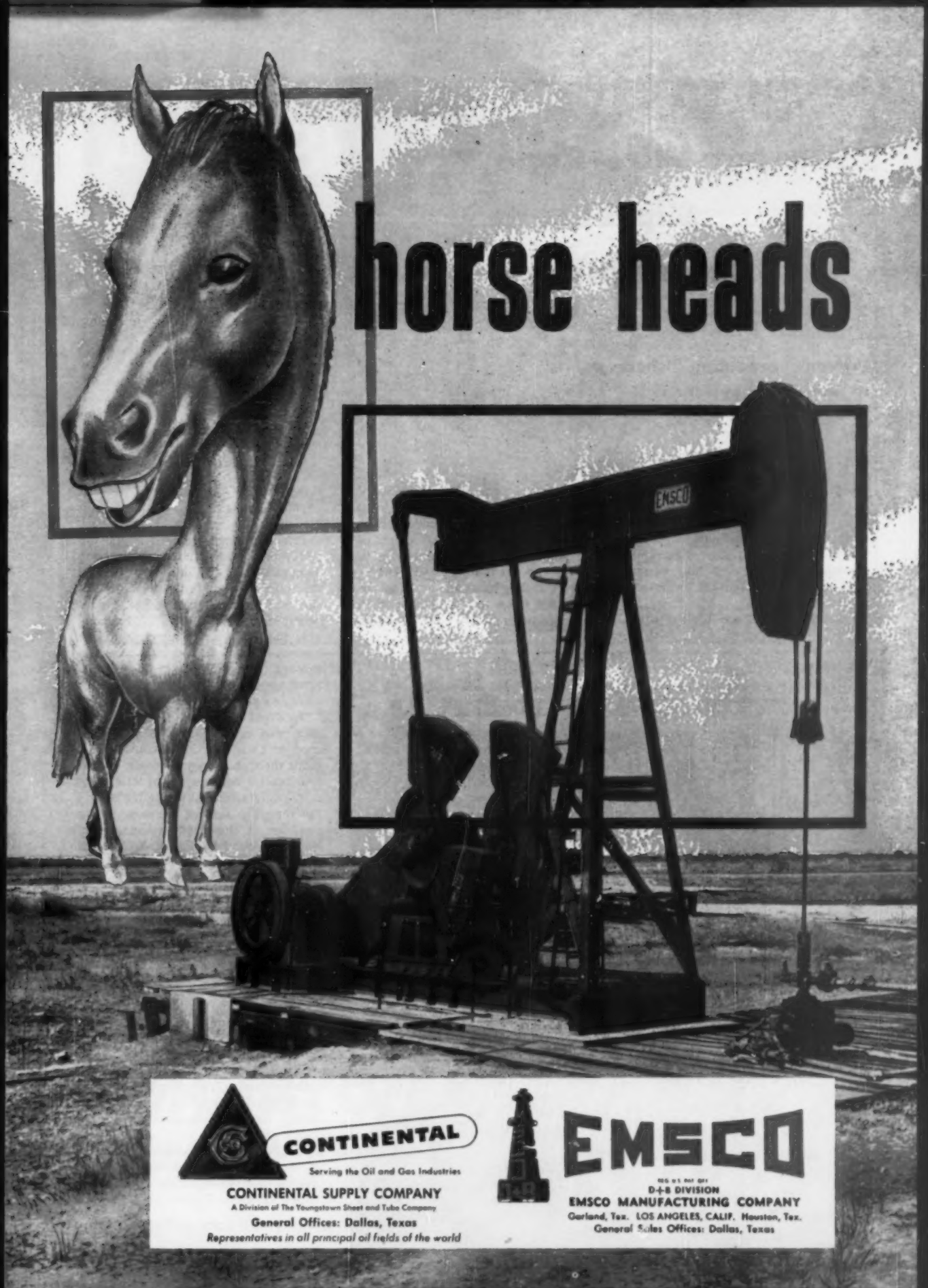

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Pocket calculator simplifies

Proper Wire-Rope Slip-Length Determination

Prevents repeating "shock points" in the block system

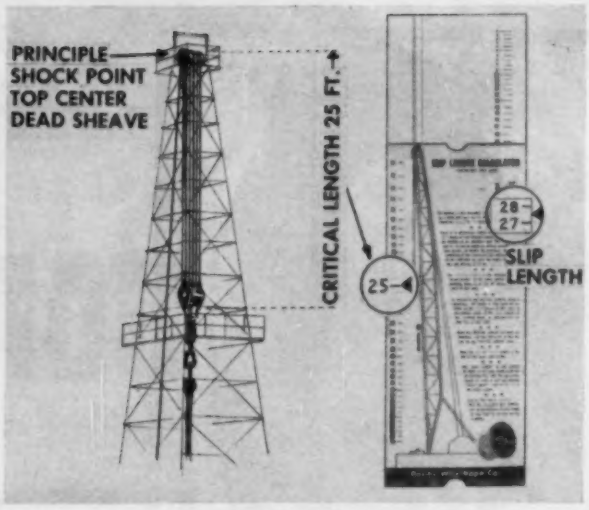
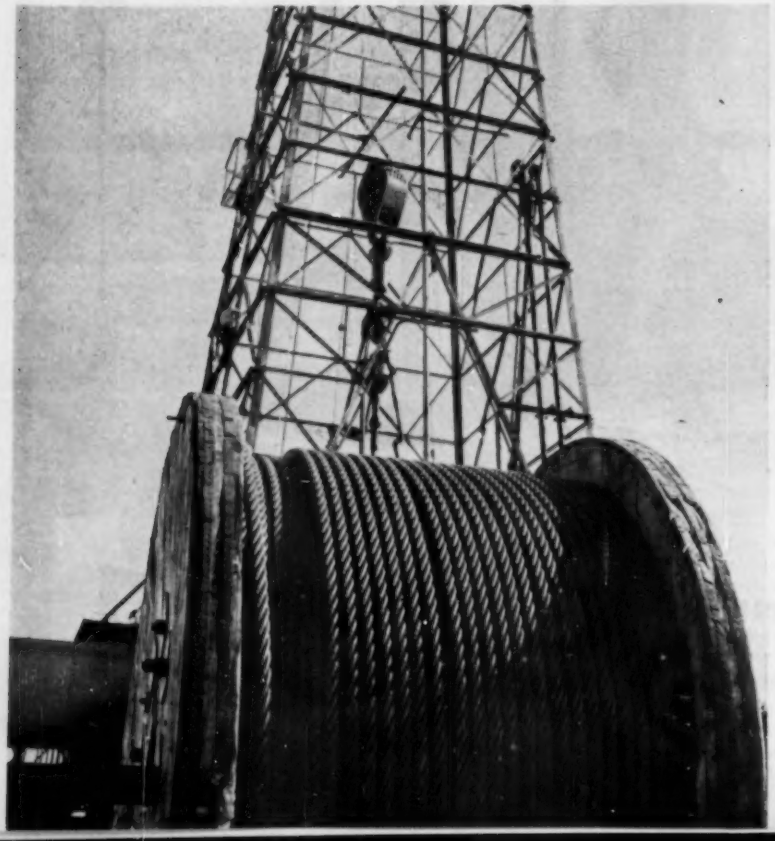


FIG. 1. MEASURING CRITICAL LENGTH at left and how to use it on the pocket slip-length calculator at right.

AMONG the heavy expense items in drilling, wire rope costs loom high. Wire rope design and manufacturing methods have been steadily improved, but to take full advantage of these improvements and secure long service life, good slip and cut-off procedures must be followed.

The driller can see broken wires, worn strands and other evidence of wear. His experienced eye spots visual wear quickly, but not hidden shock-point damage. These shock points occur at the top of the sheaves in the crown and the bottom of the sheaves in the traveling block and are most concentrated when the blocks are in the UP position. They hang over the driller's head and can fail without warning if over stressed by shock-point repeats.

MORE USE FROM EXPENSIVE WIRE ROPE and better safety can be gained by proper slip-length procedure. This is a 5000-ft spool of 1¼ in. improved plow-steel drilling line used in deep drilling.



Principal shock point is at the top center of the dead sheave. Line shock damage at this point must pass through the entire block system before it is dissipated from the working line. Under "guess" slip-length procedure, conceivably this point could hit eight top or bottom sheave centers as it passes through the system. This leads to rope-breakage danger beyond the driller's ability to predetermine.

To avoid this possibility, one of two steps can be taken: (1) Slip enough rope to clear the dead sheave shock point through the entire block system (obviously a costly waste of wire rope) or (2) determine a slip length that will not repeat as slips of the same length continue. A slip-length calculator has been developed by Pacific Wire Rope Company of Los Angeles, California, to minimize the possibility of repeats of the original shock points.

This method is based on "critical line length." This is the length of line extending from the top center of the dead sheave on the crown to the bottom center of the slow sheave on the traveling block when the blocks are in the UP position.

When one-ninth is added to the "critical line length," and used as a slip length, repeats are eliminated and the driller can use regular ton-mile slip intervals and rely on visual inspection. He is certain that shock points are not being repeated dangerously in the block system.

The slip-length calculator clearly indicates the footage of line to slip or cut off to avoid repeating shock points in the system. ★ ★ ★

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by AL CAPP

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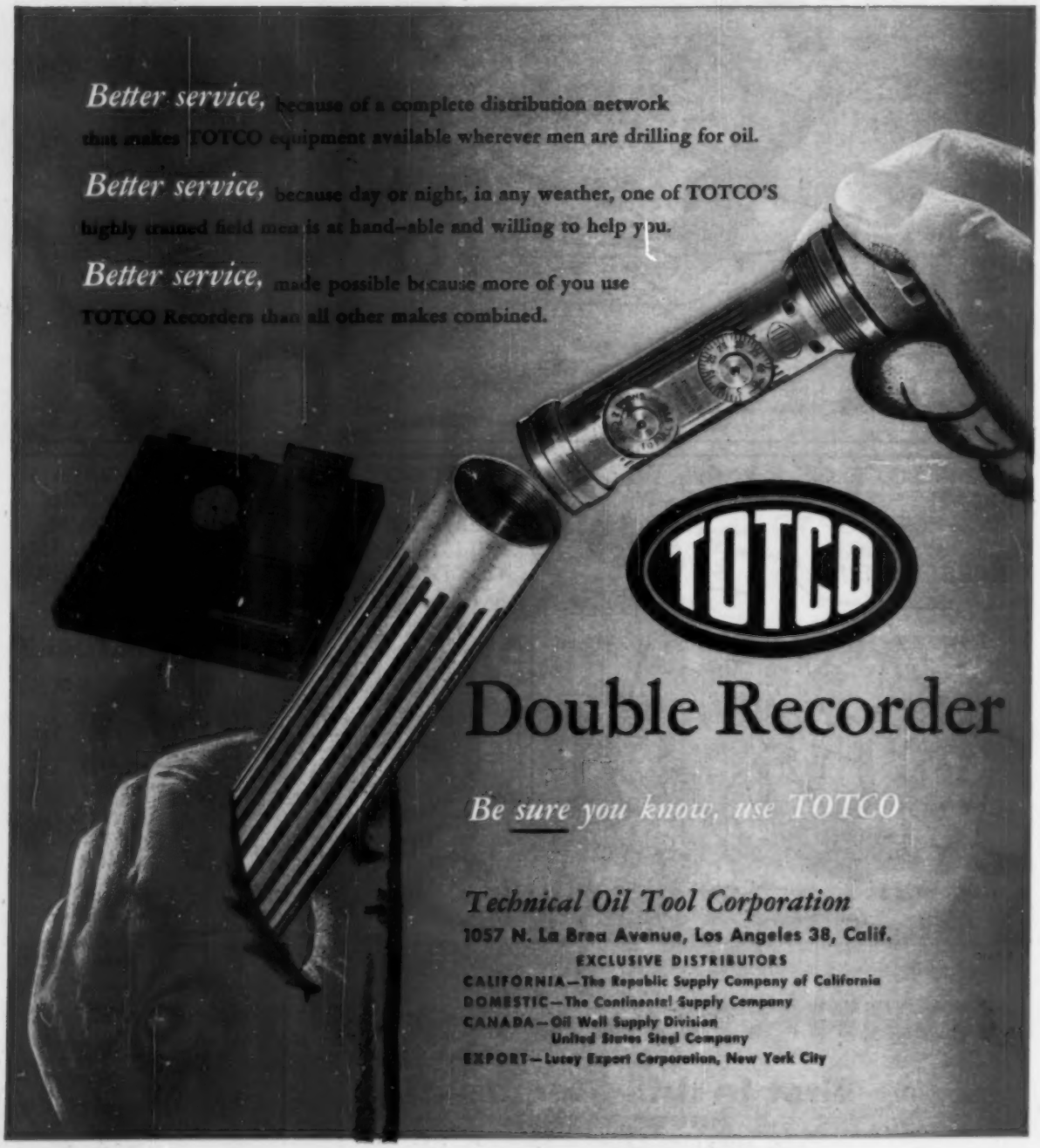
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First Successful Installation in Saskatchewan

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Pumping Dual Wells in Canada

Possibilities in Western Canada: 18 fields have multiple productive horizons

Jack Menneer
Anglo-American Exploration Ltd.
Calgary, Alberta, Canada

THE first successful dual zone pumping well in Saskatchewan was put "on the beam" in August, 1955, when new specialized equipment for dual pumping was installed for the first time in Canada. Anglo American Exploration and its affiliate, Gridoil, recently made dual completions in their Gull Lake field. Production is from the Middle Vanguard and the Upper Shaunavon at 3500 ft and 3700 ft respectively. Both zones are now being pumped by means of a single surface pumping unit. Subsurface pumps are interconnected and utilize a single rod string. The lower zone is pumped through the casing and the upper zone is pumped through the tubing to prevent co-mingling of the produced fluids. This is accomplished by means of an upper and lower packer and crossover assembly. These dual completions have substantially reduced capital expenditures and have proved quite successful.

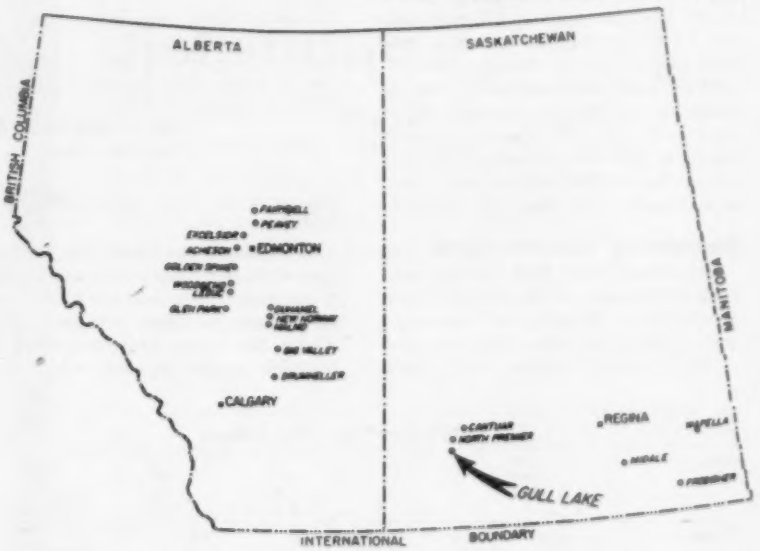
Gull Lake well 1-26A was the first successful dual producer in the Province of Saskatchewan when the installation of dual equipment was completed in August, 1955. Gull Lake well 2-26A was similarly completed the following month to substantiate and compare operating results.

Gull Lake field is in southwest Saskatchewan about 300 miles east of Calgary, 200 miles west of Regina and 80 miles north of the Canadian-US border. Some 40 wells produce 2000 bbl daily of 18-24 deg API gravity crude.

Problem: The problem was to produce dually the Middle Vanguard (3500 ft) and the Upper Shaunavon (3700 ft) by means of subsurface pumps and powered by a single surface pumping unit. For comprehensive evaluation purposes, two offset wells were selected for completion in this manner.

Well 1-26A was to be completed with a tubing pump for the upper zone and an insert-type pump for the lower zone, together with a retrievable cup-type upper packer and a retainer production packer. The second well, 2-26A, was to be completed with two

FIG. 1. **SUCCESS OF DUAL PUMPING WELLS** at Gull Lake (arrow) indicate potentialities in 18 fields in Alberta and Saskatchewan.



Canadian Dual Zone Possibilities

Alberta		Saskatchewan	
Field	Zones	Field	Zones
Acheson	Bas. qts., D2, D3	Cantuar	Cant. sd., Roseray
Big Valley (Stettler)	D2, D3	Frobisher	Charles (Ls.), Miss. Can. (Ls.)
Drumheller	D2, D3	Gull Lake	Mid. Van., Up. Shaun
Duhamel	D2, D3	Midale	Charles (Ls.), Miss. Can. (Ls.)
Excelsior	Cret. sd., D2	North Premier	Roseray, Up. Shaun
Fairydell	D2, D3	Wapella	Up. Blairmore, Wapella sd.
Glen Park	Cret. sd., D2, D3		
Golden Spike	D2, D3		
Leduc Woodbend	Bas. qts., D2, D3		
Malmo	Cret. sd., D2, D3		
New Norway	Cret. sd., D2, D3		
Peavey	Viking sd., Cret. sd.		

insert pumps, together with a retrievable cup-type packer and a retainer production packer.

The Upper Zone

The Middle Vanguard sand occurs in the entire Gull Lake area at approximately 3500 ft. The sand has a fairly uniform thickness of 18 ft. Average net pay thickness is 15 ft, average porosity is 24 per cent, and permeability ranges from 636 to 1560 md. Water saturation is 40 per cent, and the shrinkage factor is .93. Recovery is estimated at 250 bbl per acre-foot. Initial bottom-hole pressure was 1420 psig at 116 F. Bubble point is 1406 psig at this same temperature. To the north, there exists a gas cap, and an oil-water contact may exist. The producing horizon was drilled with treated native mud with a low water loss of 4 cubic centimeters on API test.

The Lower Zone

The Upper Shaunavon formation is a blanket deposition in southwest Saskatchewan, and is either a sand or a sandy limestone. Rapid lithological variations occur from south to north. In Gull Lake, the 50 ft thick Upper Shaunavon is topped at 3700 ft and it is a calcareous sandstone. The net pay averages 20 ft, and has a water saturation of 25 per cent, a shrinkage factor of .97, a bubble point of 170 psig, and the initial bottomhole pressure was 1611 psig at 114 F. Average porosity is 25 per cent, and permeability ranges from 200 to 700 md. Gravity of the crude is 24 deg API. Recovery is estimated at 230 bbl per acre-foot. This horizon was drilled with a similar mud as was used to drill the upper horizon.

Engineering Considerations

To evaluate fully both the dual production behavior of the Middle Vanguard-Upper Shaunavon reservoirs, and various dual zone equipment, two almost identical offset wells were chosen, Gull Lake wells 1-26A and 2-26A.

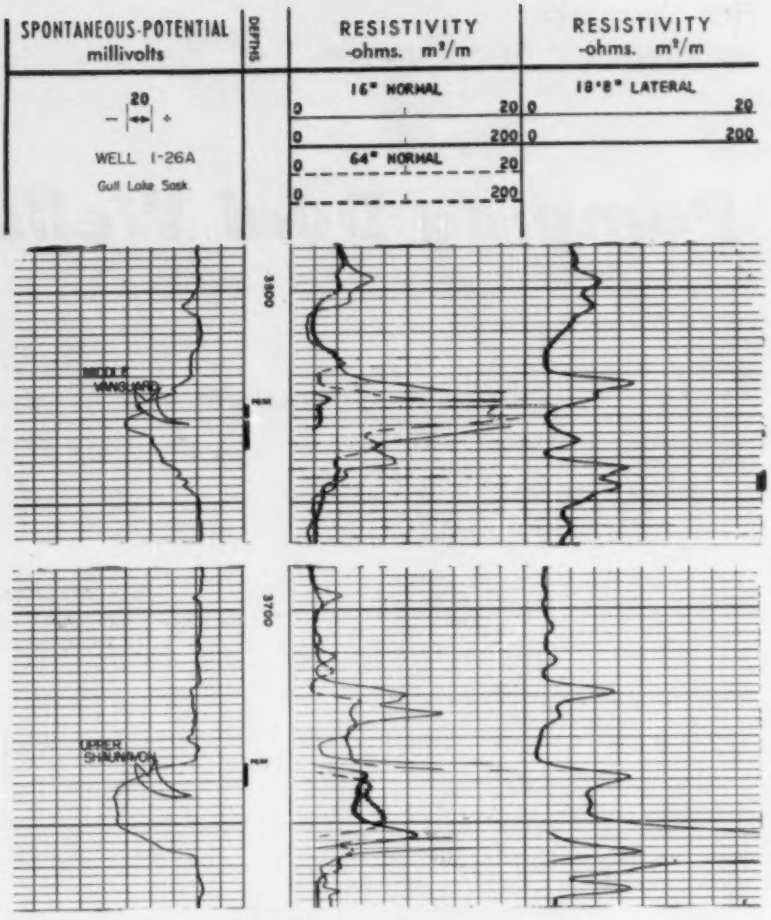


FIG. 2. **ELECTRIC LOG** of the Middle Vanguard and the Upper Shaunavon zones in Gull Lake Well 1-26A.

Completion mechanics for the two dual wells were essentially as follows: A permanent type drillable packer was set between the upper and lower pays. Above the upper zone, a special retrievable packer was set, which is a part of the tubing string. The tubing was landed on the lower packer, which has special tubing sealing nipples. Tail pipe, of reduced diameter, can be incorporated below the bottom packer. The two pumps are coupled and are run on, and actuated by, one rod string. The lower zone production initially enters the tubing and is then transferred, just above the upper packer by means of a crossover assembly, to the casing-tubing annulus. The upper zone is produced into the crossover and thence through the tubing.

Although the two methods were similar, differences occur in actual equipment installations, except, of course, for the main (lower) retainer production packer. Well 1-26A has dual pumping equipment in 7 in. casing, 2½ in. EUE tubing, and ¾ in. rods. Well 2-26A has dual pumping equipment in 5½ in. casing, with same size tubing and rods as for Well 1-26A.

In Well 1-26A, the upper packer is a special hookwall type. The polished rod pack-off has 32 chevrons (16 up and 16 down). The upper pump is a tubing type, and the lower an insert

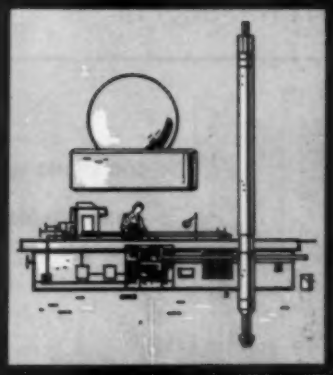
TABLE 1.—Well 1-26A data.

Casing	Size inch	Weight pounds	Grade	Depth feet	Cement sax
	10¾	32.75	H 40	332	200 + 2% $CaCl_2$
	7	20 & 23	J 55	3768	125 + 6% Gel

Horizons	Interval feet	Net pay feet	Av. poros per cent	WS per cent	Perfs feet	Type perfs
Mid Van	3512-41	13	24	40	3527.5-3537.5	4—½ in. bullets per ft
Up Shaun	3717-52	16.4	24	25	3736-3741	3—½ in. bullets per ft

Production	Pre dual		On dual	
	Mid Van	Up Shaun	Mid Van	Up Shaun
BOD	70	90	69	81
WC per cent	13	.4	11	0
CP	280	—	—	60 (P33 bean)
TP	60	—	15	—
GOR	143	25	545	35
Sand per cent	2	—	2	—
Pump (spm)	1½" x 42" x 14	1½" x 42" x 10	1¾" x 42" x 5½	1½" x 42" x 5½
Pump shoe	3408	3677	—	—
Packer	—	3709	—	—

Authorized MPRS
Mid Van 77 BOD
Up Shaun 59 BOD



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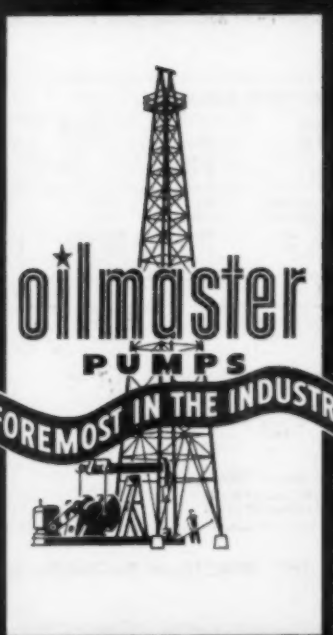

singleness of purpose

A company
devoted to a
single purpose
builds a better product.

FLUID PACKED PUMP COMPANY
Main Office and Plant, Los Nietos, Calif.

Distributed by the National Supply Co.
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type pump. The tubing pump was selected for overcoming any sand sloughing from the upper zone and to cope effectively with any gas surgance. The lower packer is 50 ft (approximately) below the Middle Vanguard perforations (upper zone), and 126 ft of 2 in. EUE 8rd thd tubing is below the packer. The bottom pump is 98 ft below the lower packer and 58 ft above the Upper Shaunavon perforations (lower zone). The upper pump is 104 ft above its productive horizon. Pumps are 265 ft apart, and packers 160 feet apart.

In Well 2-26A, the upper packer is a compression type, which permits the tubing to be anchored at both pump seats. There is no danger of seal movement in the lower retainer production packer due to pump impulse loading. Furthermore, the tubing does not require rotation for setting the packer. Packoff is by compression. Swabbing effects would be nil on pulling the packer out.

Perforated nipples form part of the crossover assembly, and an upper seal is installed. Metal-to-metal seals pack off the polished rod. Both pumps are insert types. The lower packer is 100 ft (approximately) below the upper zone perforations, and carries one perforated joint of production tubing below it. The bottom pump is just above the bottom packer, that is 97 ft above the lower perforations, and the upper pump 96 ft above its horizon. The pumps are 190 ft apart, and packers 203 feet.

It is to be noted the two types of equipment were set at different depths, to provide a better operational comparison.

Co-mingling of the two crudes within the well is prohibitive, and 800 psi pressure tests were made on the equipment when installed in the well.

The formation breakdown pressure for both Middle Vanguard and Upper Shaunavon is 1800 psi, and the two zones were open to perforations. Bleedaway would be negligible at 800 psi surface pump pressure. Therefore, 800 psi was selected as a reliable test pressure.

Dual Completion, Well 1-26A

In December, 1954, Well 1-26A was drilled through the Upper Shaunavon to a total depth of 3769 ft. The 7-in. casing was cemented 1 ft off bottom with 125 sacks cement and 6 per cent gel. The well was chosen as an initial test for Middle Vanguard production evaluation, and the zone was perforated from 3527.5 ft to 3537.5 with four ½ in. bullets per foot. The Upper Shaunavon remained cased-off. A 1½ in. x 12 ft traveling barrel pump with a bottom friction hold down was run

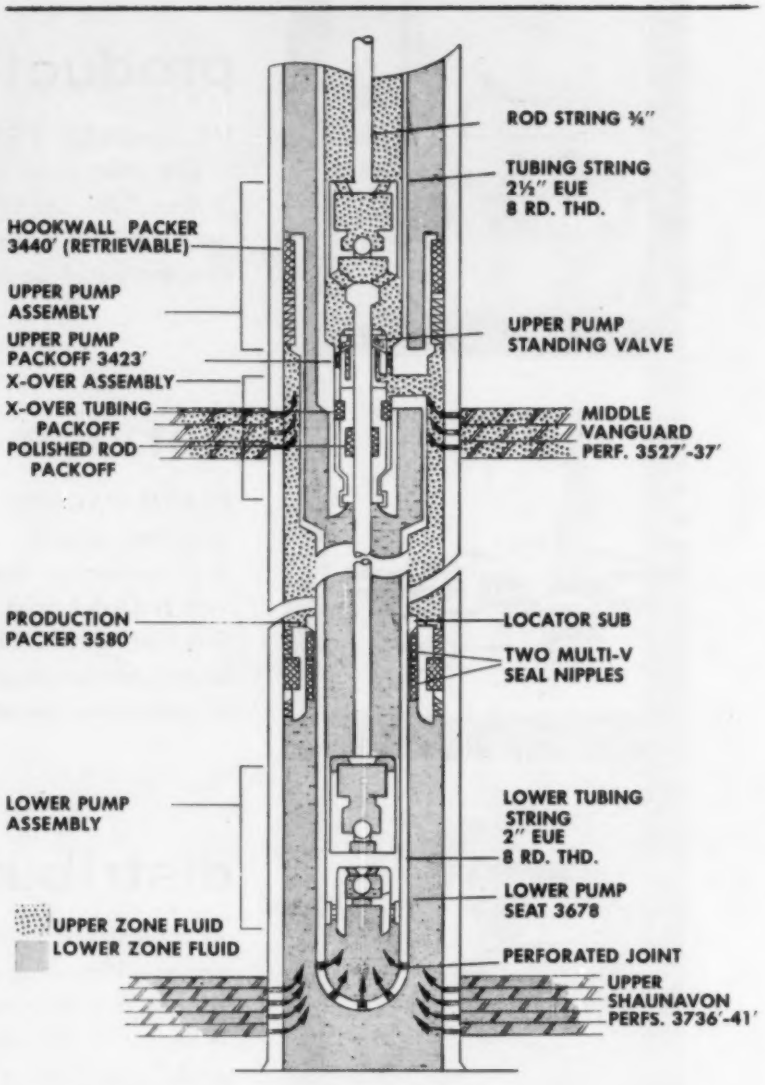


FIG. 3. **DUAL PUMP COMPLETION** of Well 1-26A, showing schemmatic cross section of lower insert pump and upper tubing pump.

TABLE 2.—Well 2-26A data.

Casing	Size inches	Weight pounds	Grade	Depth feet	Cement sax
	10¾	32.75	H 40	302	250 + 2% CaCl₂
	5½	14 & 15.5	J 55	3797	125 + 6% Gel

Horizons	Interval feet	Net pay feet	Av. poros per cent	WS per cent	Perfs feet	Type perfs
Mid Van	3530–52	16	24	40	3533–3539	3 – ½ in. bullets per ft
Up Shaun	3742–62	17	24	25	3744–3754	4 expendable jets per ft

Production	Pre dual		On dual	
	Mid Van	Up Shaun	Mid Van	Up Shaun
BOD	75	97	80	97
WC per cent	13	—	11	—
CP	360	—	—	35
TP	26	—	40	—
GOR	328	25	516	45
Sand per cent	.2	—	—	—
Pump (spm)	1½" x 42" x 10	1¾" x 42" x 9	1¼" x 42" x 10	1½" x 42" x 10
Pump shoe	3511	3412	—	—
Packer	3547	—	—	—

Authorized MPRS
Mid Van 101 BOD
Up Shaun 97 BOD

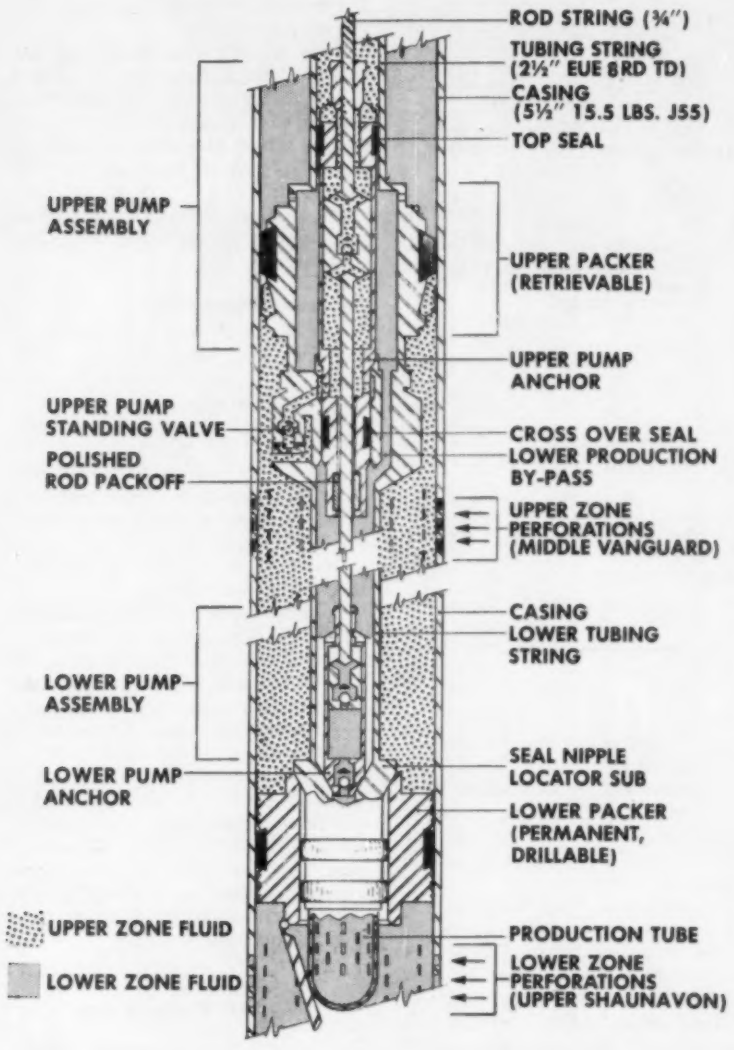


FIG. 4. **RETRIEVABLE PACKER** was employed as the upper seal in Gull Lake Well 2-26A to permit the installation of two insert type pumps. This is a schemmatic cross section of the dual pump completion.

and seated at 3531 ft opposite the perforations. Due to an unconsolidated sand, sloughing occurred during the early production period. It was found that no sand trouble persisted when the pump was raised 100 ft above the perforations.

The Middle Vanguard was test-produced for 7 months with a daily average production of 70 bbl oil per day, water cut 13 per cent, and a gas-oil ratio of 143-500 cu ft per barrel.

In July, 1955, the Upper Shaunavon was perforated from 3736 ft—3741 ft with three ½ in. bullets per foot. The Middle Vanguard was packed-off to test produce the Upper Shaunavon, which yielded 90 bbl oil per day, water cut .4 per cent, and GOR of 25 cu ft per barrel.

In late August, 1955, operations were commenced to produce dually the Middle Vanguard and the Upper Shaunavon. The program included:

1. Pull rods and pump.
2. Unseat packer at 3709 ft.
3. Lower tubing to 3748 ft approximately (that is, just above top of cement), and circulate with oil for 16 hr at least. (A long circulating period was stipulated, as a prerequisite of dual completion is that the well be thoroughly clean.)
4. Pull out.
5. Run in with casing scraper (very important).
6. Circulate for at least 2 hours on bottom.
7. Pull out.
8. Run production packer on wire line and set electrically at approximately 3580 ft.
9. Run and land sealing nipples on 2½-in. tubing.
10. Pressure test packer, above and below at 800 psi, through casing and tubing, respectively.
11. Pull tubing and seal nipples.
12. Run 7 in., 20 lb element, retrievable cup-type upper packer and crossover assembly for setting at approximately 3430 ft. (Four joints 2 in. EUE 8rd thd tubing to be below lower packer.) Due to mechanical difficulties, a special 7 in. dual zone hookwall packer was run instead of the cup type. The polish rod pack-off assembly was installed, and was to be retrieved with an overshot.
13. Set upper packer.
14. Test, separately, at 800 psi through casing and tubing, for seal-off above and below packer respectively.
15. Retrieve polish rod assembly.
16. Run pumps and assemblies.

TABLE 3.—Well 2-26A
Tubing String Assembly From Bottom

	Feet
1—2 in. Perf nipple	10.55
2—Sealing sections for retainer packer	2.63
1—Locator sub w/2½ in by 2 ft tubing pup joint	3.23
1—2½ in. EUE 8rd thd tubing swage w/collar	.75
1—2 in. EUE 8rd thd mechanical seating shoe w/collar	.72
5—Joints 2 in. EUE 8rd thd tubing	154.93
1—2 in. by 2½ in. EUE 8rd thd tubing swage w/collar	.79
1—2½ in. EUE 8rd thd safety joint	1.13
1—Joint 2½ in. EUE 8rd thd tubing	30.02
1—Crossover shoe, collar, upper by-pass jacket	11.41
1— Dual zone pump packer	3.72
1—Upper extension and top seating nipple	5.13
1—2½ in. by 4 ft EUE 8rd thd tubing pup joint	4.54
	229.55

TABLE 4.—Well 2-26A
Sucker Rod String Assembly From Bottom

	Feet
1—2 in. by 1½ in. by 12 ft Volume producer pump	13.44
1—¾ in. by 4 ft Poney rod	4.05
1—¾ in. by 4 ft Poney rod	4.10
1—¾ in. 2 ft by Poney rod	3.00
6—¾ in. by 25 ft Sucker rods	150.00
Polished rod and pack-off assembly	13.26
Upper pump assembly 2½ in. by 15 ft by 17 ft	20.00
	207.85
¾ in. Sucker rods	To surface

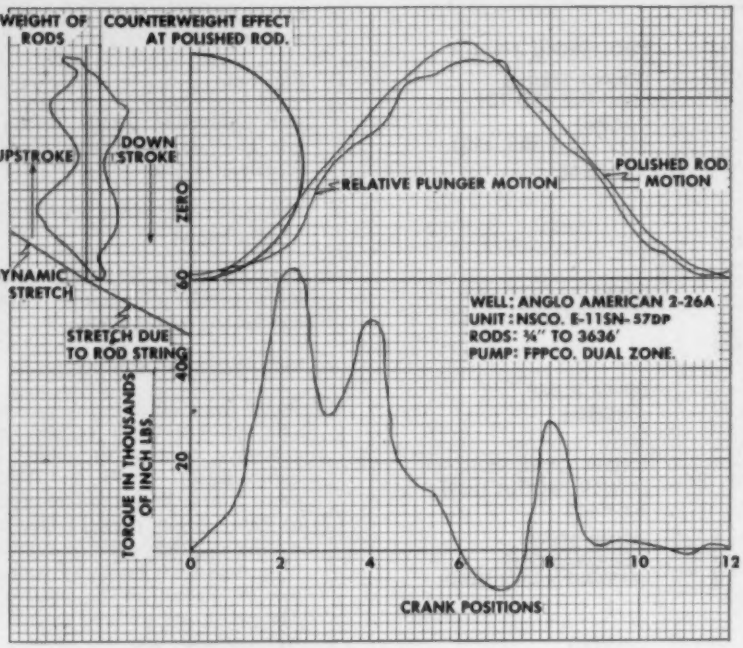


FIG. 5. **DYNAMOMETER ANALYSIS** of dual pumping Well 2-26A.

Dual Completion, Well 2-26A

Since original completion, the Upper Shaunavon in Well 2-26A had produced continuously for 18 months at its allowable of 97 bbl oil per day. Prior to dual completion in September, 1955, the Middle Vanguard was test produced for a short period at 75 bbl per day, WC 13 per cent, and a gas oil ratio of 328 cu ft per barrel. (The Middle Vanguard had been cased-off for two years, and a 500 gal mud acid job was required to bring the pay on to production.)

Program items 1-7 as listed in Well 1-26A, were carried out in a similar manner, but the dual completion equipment was a different type and is described hereunder.

The main packer was wire line set, and pressure tested satisfactorily at 800 psi above and below. Tubing was run up to the crossover shoe, (Tables 3 and 4) and then set in the slips, and the lower pump and rods were run to seat the pump—this point was marked on the rods. The rods and pump were pulled out. This procedure was for a trial spacing of the pumps on the surface and not to rely absolutely on tape line measurements. (By tubing, the seat tallied 186.87 ft, and by rods 186.85 ft. Thus, the trial spacing avoided any possible error.)

Next, the tubing assembly and remainder of tubing was run. When the locator sub (that had been already on the retainer production packer) touched down on its seat in the retainer, the proper tubing subs were installed so as to locate the surface equipment in the desired position. The upper packer had to be set. Thus, by setting 4000 lb tubing weight down on the locator sub of the main packer, the snap ring in the upper packer collapsed. Then, additional 5000 lb tubing weight was applied to secure the upper packer seal.

After landing the tubing, the lower insert pump, six sucker rods, and the upper pump assembly were installed. The remainder of the rods were run, and the pumps seated.

Tests for effective seal-off on the dual zone installations were performed by pressuring-up with the down-the-hole insert pumps. Separately, the casing and tubing pressures were built-up to 800 psi, which were test held for 15 min.

The well was placed on dual production, and the job had taken only 27 hr rig time.

Pumping Mechanics

The two wells had a dynamometer test when dual production had stabilized and in general, both wells were pumping satisfactorily.

Maximum working load in Well 1-26A was 8200 lb, or 72 per cent maximum permissible. Similarly, Well 2-26A was 8750 lb, or 79 per cent. Unit 2-26A was operating near peak torque permissible at 60,500 in. lb, and 1-26A at 38,400 in. lb, or 63 per cent of maximum permissible torque.

A small increase in counterbalance weight for Well 2-26A was necessary. The two inflections that occur on the dynograph chart, Well 2-26A, are due in all probability to a slightly fast pump speed. A reduction from 10 spm to 8 is preferable.

Pump efficiencies in Well 1-26A were 103 per cent for the upper and 84 per cent for the lower, and similarly, Well 2-26A 117 per cent and 89 per cent. The "over efficiency" of the upper pumps is caused by a partial flowing condition, and the pump action is, in part, an agitation.

TABLE 5.—Pump data.

	Well 1-26A	Well 2-26A
Min. working load (lb)	4,300	3,590
Max. working load (lb)	8,200	8,750
Max. permissible load (lb)	11,300	11,000
Av. upstroke load (lb)	7,200	7,050
Av. downstroke load (lb)	5,000	4,950
Actual counterbalance (lb)	6,100	5,076
Polished rod hp	1.63	2.34
Peak torque, working (in., lb)	38,400	60,500
Max. permissible peak torque (in., lb)	60,500	57,000
	Well 1-26A	Well 2-26A
Pump efficiency:		
Upper	103 per cent (1¾ in. by 42 in. by 5½ spm)	117 per cent (1¾ in. by 42 in. by 10 spm)
Lower	84 per cent (1½ in. by 42 in. by 5½ spm)	89 per cent (1½ in. by 42 in. by 10 spm)

Economics

Successful dual completions avoid the drilling of an additional hole, reducing capital expenditures considerably. To complete a single zone Gull Lake well the cost breakdown would be thus:

Drilling	15,000
Casing & Equipment	18,600
Portion battery cost	2,000
	$35,600

The Author

Jack Menneer is head of the petroleum engineering department of Anglo American Exploration, Ltd., at Calgary, Alberta, Canada. He was born and educated in England and qualified at the Camborne (Cornwall) School of Mines. He served 6 years with the Royal Engineers in the European theater during World War II. As an exploitation engineer with the Shell Group, he worked in Colombia and Venezuela, South America, and was with Magnolia (Mobil Oil) in the Gulf Coast Division, Texas. Prior to joining Anglo American, Menneer was drilling and producing editor for The Petroleum Engineer.

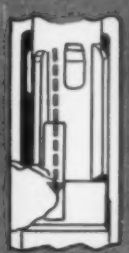
DESIGNED for RUNNING

As part of the Drill String

The SHAFFER-WAGGENER BUMPER SAFETY JOINT protects 2 WAYS!

For safeguarding your drilling well against the hazards of a stuck drill string, nothing surpasses the *two-way* protection provided by the Shaffer-Waggener Bumper Safety Joint. Here's a tool—*specifically designed to withstand the continuous torque and vibration of running directly in the drill string*—that can be relied upon to provide sharp down-jarring at any time the drill string becomes stuck. Or, with equal ease, it provides quick release from the stuck portion for recovery of the string above the tool.

No other tool—or combination of tools—provides the ruggedness, the versatility, the simplicity, the all-around drill string protection you get in the Shaffer-Waggener Bumper Safety Joint!



TO RELEASE, *tool is tripped, moving drive keys downward.*

LEFT TORQUE *thus rotates drive keys into unlocking slot as string is raised.*

1 RUN THE TOOL IN THE DRILL STRING—it's specifically designed to withstand the continuous torque and vibration of modern drilling operations. The tool has been used successfully throughout the world—and at world-record depths. At all depths it provides the extra safety of double drill string protection!

2 TO USE FOR JARRING, simply slack off weight of approximately 2,000 feet of drill pipe onto the tool. This weight releases the tripping mechanism and strikes a sharp downward blow. Raising the string automatically re-sets the tool for another blow—and repeated blows can be struck as fast as the string can be raised and lowered. *It's as simple and positive as that!*

3 TO RELEASE, in the event jarring will not loosen the stuck string, simply trip the tool and apply reverse torque as the string is slowly raised. One-sixth turn of the drive keys rotates them into an unlocking slot so that complete release is obtained by continuing to raise the string.

4 THE TOOL TRANSMITS TORQUE LOADS in either direction through drive keys—*not through threads*—a *big advantage* over conventional safety joints. In fact, until the definite releasing operations are performed in proper sequence, the tool remains the strongest joint in the drill string. Yet by first tripping the tool, it can be quickly released.

5 THE TOOL CAN BE RE-CONNECTED in the hole by simply using the recovered portion at the bottom of a fishing string for mating with the portion left on top of the fish. It's simple, quick!

Locked Position (for drilling)

Tripped Position

Added Proof

These typical job records further show the all-around utility of the Shaffer-Waggener Bumper Safety Joint . . .

3½ MILES DEEP: On this job, the Bumper Safety Joint was released from stuck drill collars at 18,136 ft. (almost 3½ *miles* deep) requiring only 2¾ turns of reverse torque *at the table*. Recovered portion of tool was then attached to bottom of fishing string, run back into hole and connected to fish. After jarring, bit and drill collars were freed, leaving hole completely clean!

3 MILES DEEP: On another job at 16,883 ft. (over 3 *miles* deep) a Bumper Safety Joint being run in the drill string greatly simplified recovery of a parted and dropped string, again leaving hole completely clean!

SLANT HOLES—a problem with conventional safety tools—are no obstacle to the Shaffer-Waggener Bumper Safety Joint. Even directionally-drilled wells with extreme slant are handled in stride.

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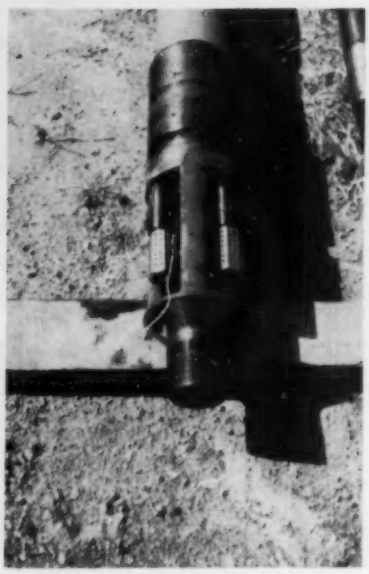
33 years OF OIL TOOL LEADERSHIP

Photos show equipment for well 2-26A

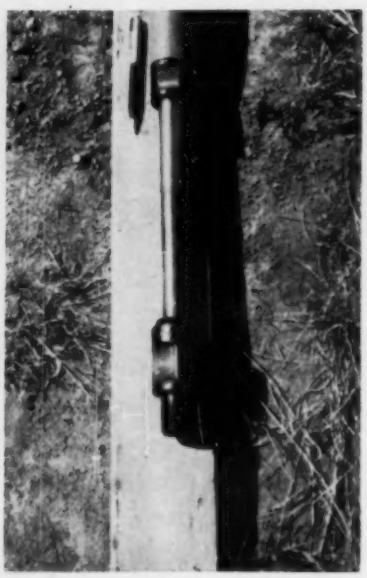
DRILLABLE PRODUCTION PACKER being prepared for running on wire line.

RETRIEVABLE PACKER with ports at top to permit lower production into the casing annulus.

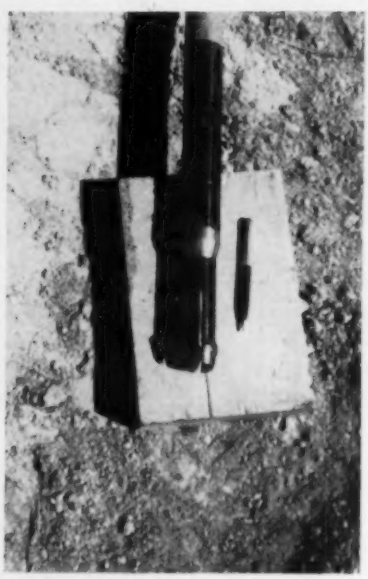


CROSSOVER ASSEMBLY. Fluid from upper zone flows through ball and seat strainer nipples. Lower zone fluid is channeled internally.

BOTTOM OF POLISH ROD PACK-OFF. Perforated nipple above sealing cups allows upper zone fluid to enter upper pump.



POLISH ROD PACK-OFF shown beside pencil, and is a metal-to-metal seal.



BOTTOM MECHANICAL LOCK for lower insert pump.

Cost for Dual Completion:

Dual pumping equipment (including upper and main packers and two pumps) .	2,100
Service rig time	500
	$2,600

For Gull Lake, a dual completion costs approximately $2600 per well, and saves an approximate $32,000 capital expenditure for drilling and completing an additional well. Payout for the dual completion would be one month, which is obviously a favorable investment. Such is particularly the case where an operator is confronted with relatively thin productive formations.

Acknowledgment

The author is grateful to Anglo American Exploration for permission to publish this paper. Thanks is expressed for supervision of the dual completions to R. Armstrong, D & B Pumps; Cliff Taylor, Baker Oil Tools; J. Clements, Fluid Pack Pumps; especially to H. Palmour, who came up from Fluid Pack Pumps, Fort Worth, Texas; the Production Department, Anglo American Exploration, and to G. Manson, National Supply Company, for dynamometer tests. ★ ★ ★

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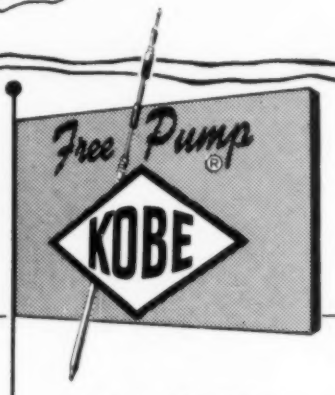

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EXCLUSIVE

Skelly Drills 132 Hits In . . . .

Fracturing credited with Flowers Field, West Texas, success story

Andrew M. Rowley
Oil Columnist

ON a lease in Stonewall County, West Texas, previously condemned by a dry hole, Skelly Oil Company has completed 132 producing wells without getting a dry hole. The first well on the property by Skelly had an initial production of 933 bbl of oil per day. All 132 producers on the lease now are flowing their allowable of 40 bbl per day, calendar day basis.

Since the first well was completed January 8, 1951 until July of 1955, more than 3,500,000 bbl of oil have been produced from the 5760-acre lease.

Development of the lease, in what is now the Flowers and West Flowers field, is continuing. Skelly has three rigs now running and has several promising locations staked for drilling soon.

Most recent completion, in November, 1955, flowed 418 bbl of 41 deg oil on the initial potential test. Productive zone is at about 4200 ft.

When the lease was purchased in 1947, nearest crude production was in the Hamlin sector of Fisher County, some 15 to 20 miles to the south. Only subsurface data available for the study came from logs of the one dry hole on the lease.

As records show that 8 out of every 9 wildcat wells drilled are dry holes, many consider this Skelly tract to be one of the most remarkable oil leases anywhere. As far as is known, there is not another lease on which so many wells, including the first test, were completed without a dry hole.

Skelly was first attracted to the lease when company engineers examined the log of the well drilled in 1939 and abandoned as a dry hole. This well had penetrated 100 ft of Canyon sand. These engineers decided the horizon had either not been tested properly or that it was too hard and tight to give up its oil.

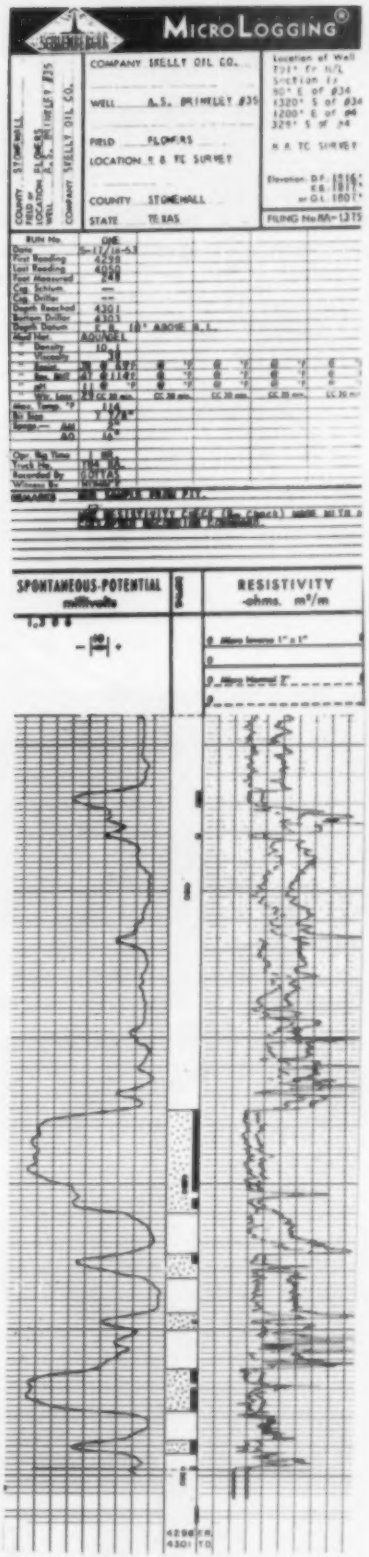
Property was then leased and, after surface mapping, began extensive exploratory work. A program of core drilling and seismic surveying followed. The company started its first test on the property in 1950 and completed the well January 8, 1951. The location was about one-half mile from the dry hole abandoned in 1939.

The lease is an outstanding example of what the fracture treatment of oil-bearing horizons has meant to the petroleum industry toward increasing oil recovery.

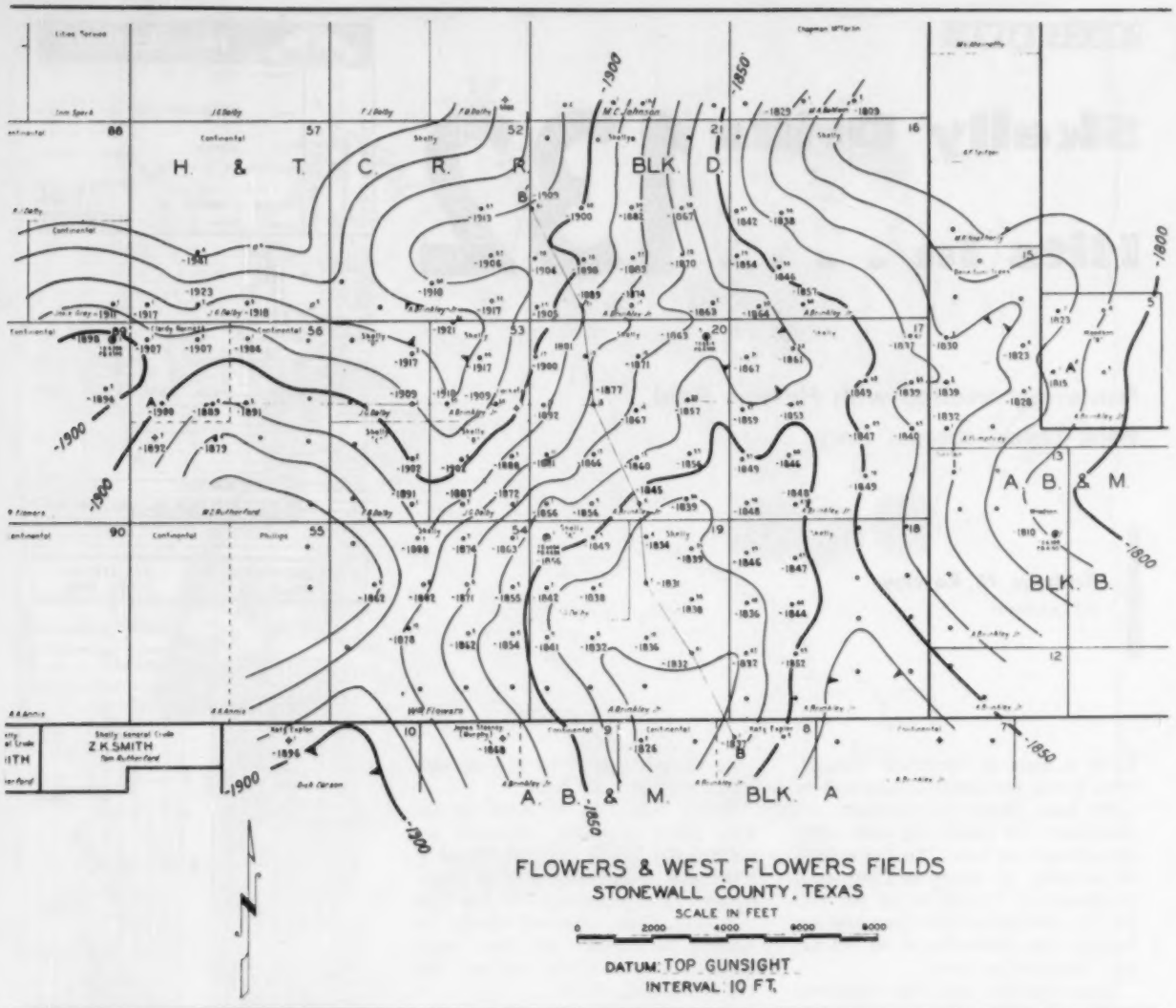
Between the time Skelly bought the lease in 1947 and completion of the first well in 1951, Stanolind Oil and Gas Company had licensed the use of its hydraulic fracturing process.

The initial Skelly well was given the fracturing treatment, and the well responded immediately with a flow of 933 bbl of 42 deg crude per day with a gas-oil ratio of 487 to 1. Total depth of the well was 4189 ft.

The company developed its lease by drilling offsets to the discovery well



Sands, *showing possible oil accumulation and zones of effective porosity, are revealed on this micro log of the No. 35 A. S. Brinkley.*


H & T C R R BLK D
A B & M BLK B
A B & M BLK A
FLOWERS & WEST FLOWERS FIELDS
STONEWALL COUNTY, TEXAS
SCALE IN FEET
0 2000 4000 6000 8000
DATUM: TOP GUNSIGHT
INTERVAL 10 FT.

Discovery well *in the Flowers field, Skelly Oil No. 2-A Dalby. Picture shows the jackknife type of drilling rigs used in the field.*

Structural map *of Flowers and West Flowers fields of Stonewall County, West Texas, contoured on top of the Gunsight formation, a limestone. Dry hole abandoned in 1939 is shown near center, east line, Section 53.*

and then offsets to these wells. As every well drilled was completed as a good oil producer, other operators began to take up leases around the Skelly block of nine sections. By the time Skelly had located wells towards the outskirts of its lease, all tracts surrounding its 5760 acres had been leased.

Production has extended beyond the Skelly lease, and at this time there are 177 producing wells in the Flowers and West Flowers fields.

One of the wells, drilled alongside the dry hole drilled in 1939, had an initial potential test flow of 885 bbl per day, after fracturing treatment. The company completed one well that flowed 1431 bbl per day; several wells came in with initial production exceeding 1000 bbl per day.

Pay section in the Flowers field is made up of a series of sandstone lenses in the Canyon series of the Pennsylvanian system, as explained by Dr. W. F. Bailey, exploration manager for Skelly. The reservoir is a stratigraphic trap formed by the lenticular sandstone beds pinching out up dip to the east. The zone of sand lenses ranges from 50 to 125 ft thick with effective porosity ranging from 10 to 85 ft. The sandstone is very fine grained, hard, and silty with low porosity and permeability. Production from the reservoir, according to Bailey, is made possible by the multiple-stage fracture treatment.

Three wells in the Flowers field have been drilled to depths of around 6500 ft to test the Ellenburger and other pre-Canyon formations. No production has been developed to date from these deeper zones. ★ ★ ★

NEW PRODUCTION SCHOOL GRADUATES FIRST CLASS

Roy Willis of the Atlantic Refining Company directs discussion on hydraulic pumping techniques.

TWENTY-FIVE men from some 16 producing companies were graduated in the first Fall term of the School of Production Technology located at Kilgore College in Kilgore, Texas. Members of the class were foremen, superintendents, and engineers with field experience ranging up to 18 years and were sent to the school by their companies from the U. S. and Canada and as far away as Brazil and Venezuela in South American. Plans are being made for the spring term which will begin February 13, 1956.

The seven weeks course devoted to production techniques is sponsored jointly by the American Petroleum Institute and the Petroleum Extension Service of the University of Texas. It is reported to be the first school of this type to be offered primarily for the production phase of the industry.

The intent of the school is to provide training for supervisors and prospective supervisors in the field of oil and gas production. The curriculum, which was selected by a committee authorized by the Vocational Training Committee of the API, production division, combines both technical and practical presentations. Patterned after the successful School of Drilling Technology sponsored by the AAODC, instructors are drawn from oil producing and field service companies and are experts in their respective fields. The course schedule includes public relations, exploration and field development, completion practice, production maintenance, artificial lift, and other subjects vital to the efficient production of wells.

Those in attendance generally agreed that the course had been most successful and was of considerable benefit to them. All recommended the continuance of the school and its service to the industry. Certain changes in the course suggested by the class will be incorporated in future terms of the school. ★ ★ ★

P.E.'s Jim LeVelle describes operation of hold-down packers in well fracture treatments.

Classes feature the study of models as well as classroom lectures and field trips.

C. D. Fletcher gets ready to conduct course on gas lift valves and operation.

The class was made up of production foremen, superintendents, and engineers from throughout the Western Hemisphere.

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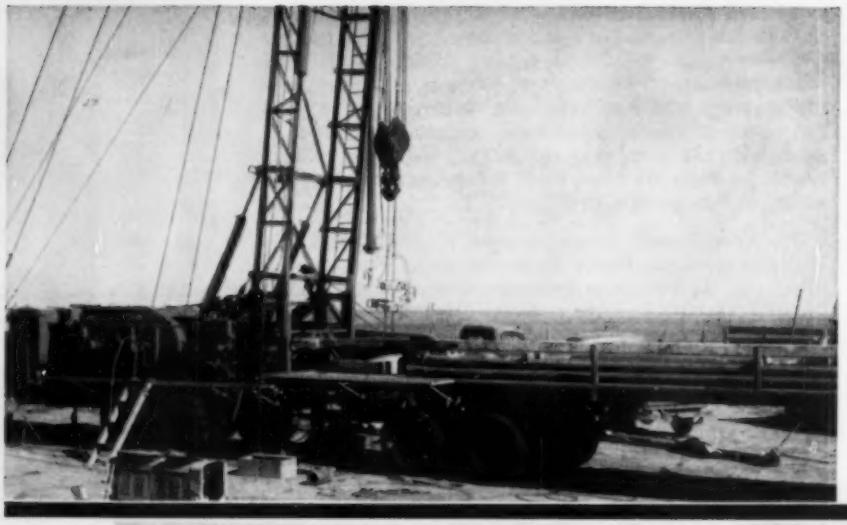

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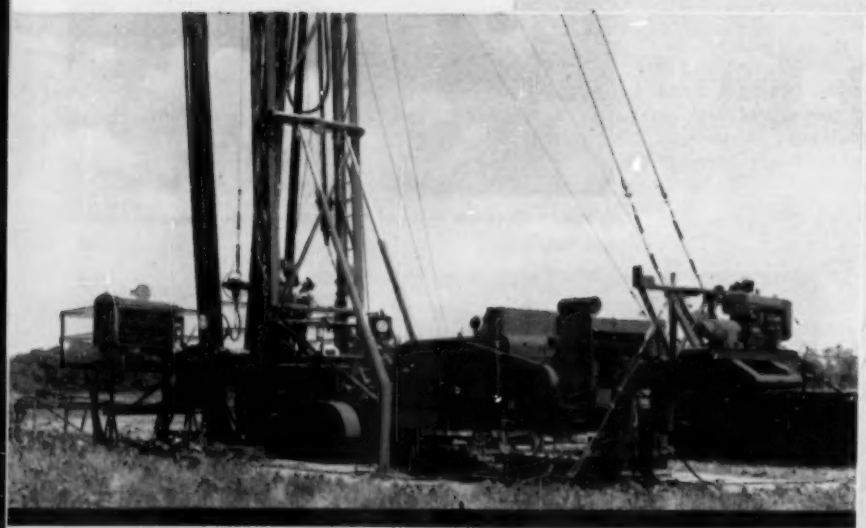

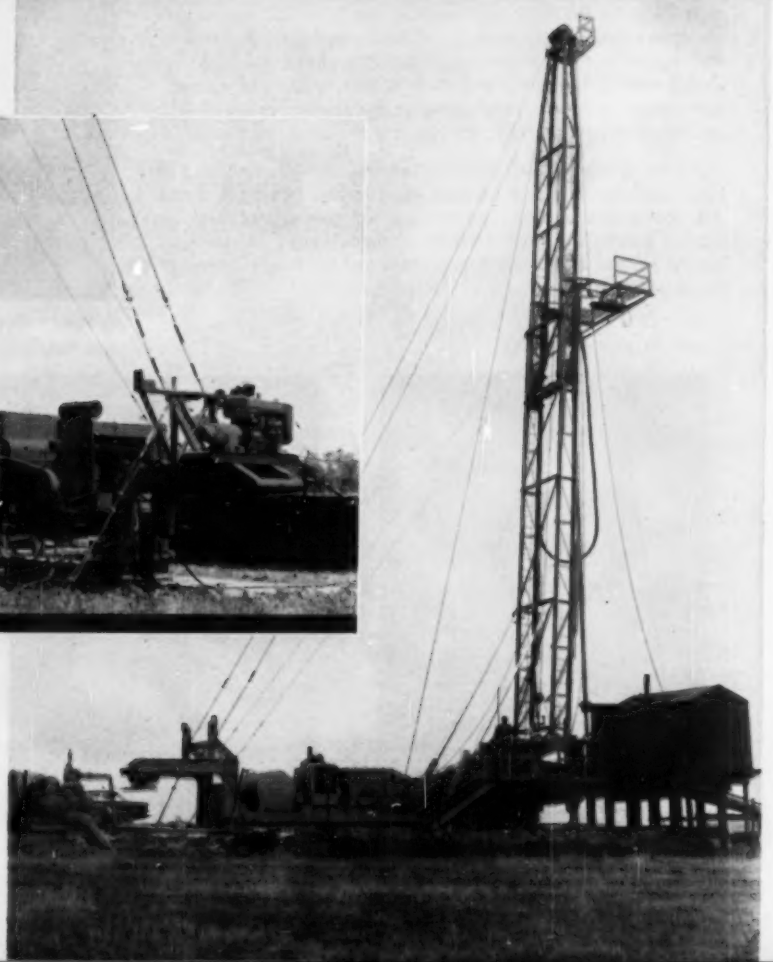

2 **Model K-200** double drum hoist mounted on Model 152 "Trailermast" with separately powered rotary table. Well adapted for 7,000-foot Slim Hole Drilling.

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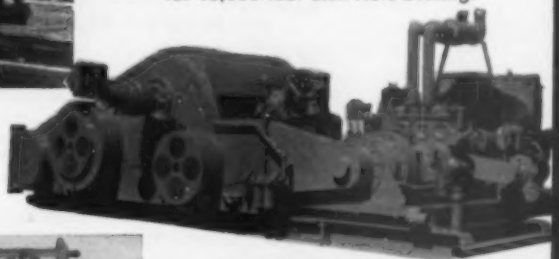

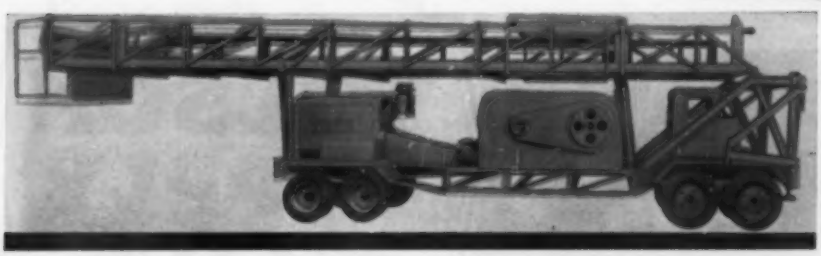

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Effects of Drilling Fluid On Penetration of Rock Bits

Basic conclusions of an 18-month project were that penetration rates were increased by: (1) rapid removal of chips from the bottom of the hole; and, (2) directing the fluid stream toward the line of contact of bit cutters and the rock. Research also verified Russian findings that the presence of electrolytes in drilling mud aid in making the rock "softer."

AN 18-month program of fundamental research to determine effects of drilling fluid on the penetration of rock bits was recently completed by Battelle Memorial Institute, Columbus, Ohio, for the American Association of Oilwell Drilling Contractors. Battelle scientists Donald Gideon, Ralph Simon, and Horace Grover, in their report to AAODC, point out that their experiments reveal two main conclusions with regard to drilling fluids and design of rock bits.

It was observed that clearing the chips quickly from the bottom of the hole, a function of drilling fluids, increases the rate of penetration by giving the drill bit an unobstructed path. To improve the penetration rate when drilling with mud, the ratio of effective viscosity to density (kinematic viscosity) should be kept as low as possible, consistent with other mud requirements. Comparative experiments indicated that the dynamic viscosity coefficient is the most important physical property of drilling mud with respect to chip clearance. Gel strength and density are of less consequence, and filtration rate has no measurable effect.

The relationship between chip clearance time and rate of flow was found also to depend upon the hydraulic system of the bit. Battelle's studies indicate that penetration rates can be increased by directing the fluid stream toward the lines of contact of the cutters and the rock formation.

Battelle's research program for the AAODC also verified that effective reduction in hardness of rock can be obtained by the use of certain electrolytes (such as caustic soda, lime, salt, aluminum chloride) in drilling mud, as previously reported by Russian investigators. Use of these chemical hardness reducers may increase the rate of penetration by a measurable degree.

Bottom of the hole studied. Much of the Battelle work for AAODC on drilling fluids was directed toward the behavior of mud and cuttings at the bottom of the hole, rather than in the annular space. Other researchers had previously done a large amount of work to find the relationships between the fluid properties and the velocity of the chips carried upward in the space between the drill string and the wall of the hole.

Special apparatus was constructed to assure that the experiments would be conducted under carefully controlled conditions. To study the action of drilling fluids on cuttings where the chips are formed, a clear plastic model of a hole bottom was built. Aluminum chips were substituted for limestone to permit a standard basis for comparison.

Comparison of roller bits. Tests were made on the comparative action of standard and jet roller bits. It was found that the jet bit has an advantage of about 2 to 1 in flow rate over the standard bit. The added fluid turbulence created by forced streams from jet bit is an aid in clearing chips.

To increase flow velocity and turbulence, the jet bit was modified. A ½-in. angled tube was welded to each jet opening to direct the fluid streams toward the areas where chips were formed under each roller. Instead of the perpendicular stream of the standard jet bit, this modification resulted in an appreciable circumferential fluid velocity under the rollers. This increased the rate of chip removal.

Gideon, Simon and Grover point out the actual design of a practical bit along the lines of their modified experimental model would depend on a number of factors, such as mechanical strength. Field studies will be necessary to determine the economics of the bit in relation to pump power required to make it work efficiently. Any changes, the scientists say, will probably be a compromise between the ideal hydraulic system for optimum chip clearance and a long-lived bit yielding maximum drilled hole per dollar.

Studies of drilling fluids. Further experiments were carried out to determine the relative effectiveness of

Editor's Note: *In March, 1954, the Battelle Memorial Institute of Columbus, Ohio, undertook a basic research project sponsored by the American Association of Oilwell Drilling Contractors to investigate the effects of drilling fluids on the rate of bit penetration. The study was concluded August 31, 1955, and a 34-page report entitled "An Investigation of the Effects of Drilling Fluid on Penetration of Rock Bits" was prepared by research scientists Donald Gideon, Ralph Simon and Horace Grover for AAODC. Presented here is a review, in part, of this detailed report, much of which is reproduced verbatim. THE PETROLEUM ENGINEER wishes to thank the AAODC for permission to publish this report.*

various fluids in chip clearance. Individual tests were designed to observe the effects of different fluid properties, such as viscosity, density, filtration rate and gel strength. It was quickly observed that fluids of low viscosity, such as water, are much more effective in flushing chips than more viscous fluids, such as bentonite mud. Further experiments yielded data on other fluid properties.

A standard bit was used in a test set up to determine how effective various fluids were in removing chips from the hole bottom within a given time. Comparing the minimum flow rates required to meet the test conditions, it was found that the rate for water was 30 gallons per minute; barite mud, 40 gpm; mineral oil, 53 gpm; attapulgite mud, 65 gpm; and bentonitic mud, 80 gpm. Since the gel strength of the heavy barite mud was nearest to that of viscous attapulgite mud, the comparison was held to be significant. It showed that greater fluid density reduces the flow rate for clearance in a given time, just as would lower viscosity. At the same time, the tests illustrated the effect of gel strength. While the attapulgite mud was maintained at the same viscosity as the bentonitic mud, its gel strength was lower.

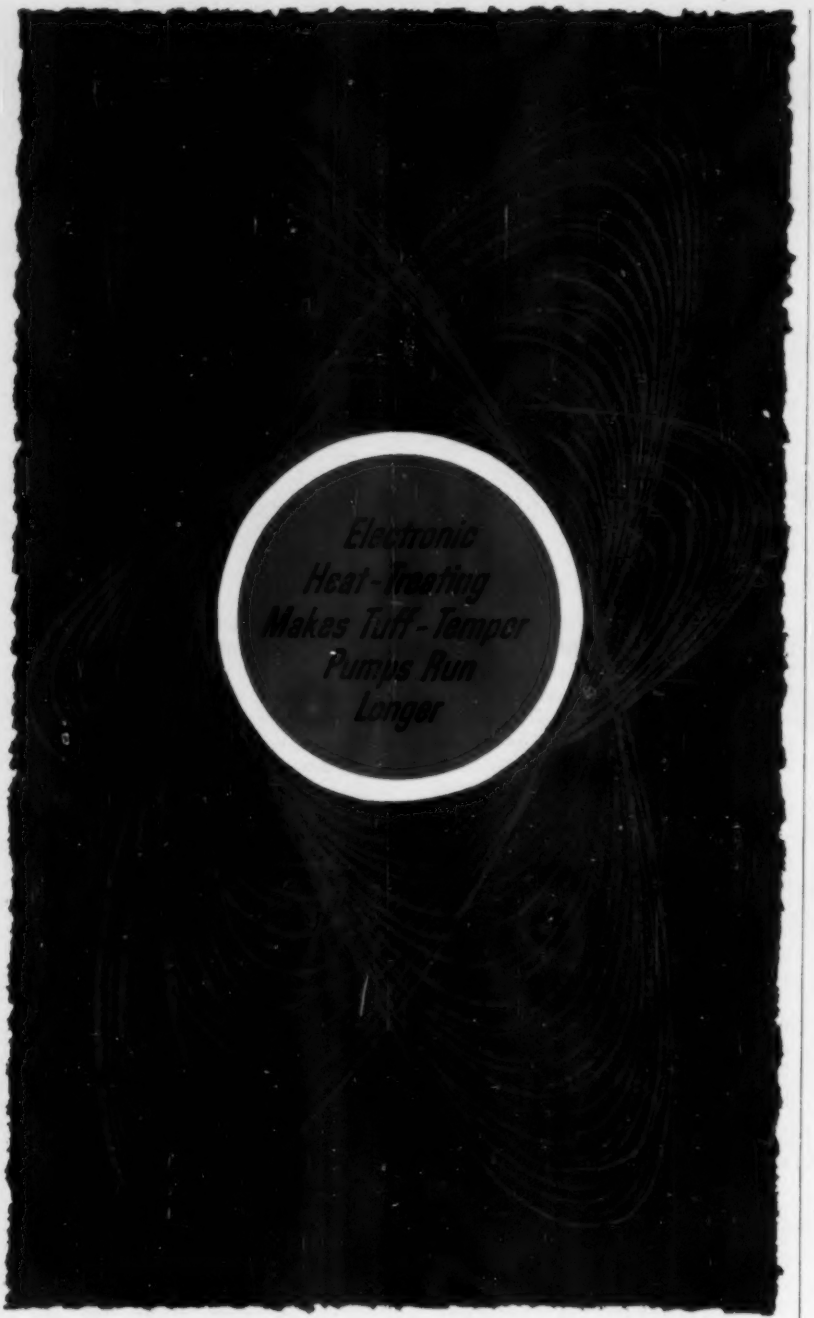
Again, the Battelle scientists emphasized that practical application of their findings depends on field studies. Compromise is necessary here, too, because drilling fluids are formulated to meet a number of requirements in addition to removing cuttings.

Because of the current interest in using air and natural gas in drilling, clearance times for air were also measured. Again it was found that the modified jet bit, with its directional blast of air, was most effective in removing chips.

Experiments with hardness reducers. Spot-checking results of lengthy studies by Russian researchers, Battelle scientists confirmed the effectiveness of "hardness reducers" in increasing drilling rates. Electrolytes used in the experiments were sodium hydroxide, calcium hydroxide, sodium carbonate, sodium silicate and sodium phosphate.

As reported by the Russians and verified by Battelle, exceedingly small concentrations of these chemicals do "soften" the rock and thereby speed the rate of penetration. There are optimum conditions for the various rocks, with reference to the amount of a specific chemical in solution. Maintaining these optimum conditions presents the biggest problem in practical application of chemical hardness reducers.

The Russian report indicates that benefits in increased penetration rate would range up to a maximum of 30 to 60 per cent. Battelle researchers cau-



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tion that these benefits must be weighed against the costs and complications in the mud program which may arise. Feasibility of practical field use will depend on the added costs of materials, equipment, and technical help to maintain the correct concentrations of chemicals in solution.

Summing up their studies for AAODC on the effects of drilling fluid on penetration of rock bits, it was emphasized that such a fundamental research program is not expected to produce a panacea for all the conditions likely to result in low penetration rates. However, by taking nothing for granted, basic research seeks to learn "why" as well as "what." The fundamental work by Battelle furnishes an indication of the nature of the trouble so that practical design and engineering can be directed in the proper channels.

The research program was patterned after the Battelle work done for Drilling Research, Inc. This work, which was a study of rock fracture with chisel edges, did not include the effects on the rock due to drilling fluids. Since this earlier work had resulted in useful relationships among the volume of rock fractured, energy and geometry of the bit, and pattern of blows on the rock, inclusion of the effects of drilling fluids in these relationships was a logical extension of this work.

Observations of Chip Clearance

Emphasis was directed toward observations of the behavior of chips on the bottom, rather than in the annular space. It had been established from tests made with the drop tester that the presence of large chips at the bottom reduces new rock breakage. It is reasonable to expect that ineffective chip removal would cause a decrease in the rate of penetration. It was guessed that drilling muds were less effective in chip removal than was water because muds have a lower flow velocity where the chip is formed for the same volume of flow due to their higher viscosity.

Fluid flow theory. When fluid flows over a chip, two types of forces are exerted: (1) buoyant force, depending on the relative densities of fluid and chip, and (2) frictional force, which increases with fluid velocity and depends on the shape and nature of the surface of the chip. Motion of the chip is opposed by friction between the chip and the surface under it, and by inertia.

It was expected that greater turbulence would increase the chance of sweeping out a chip in a given time, and the greater turbulence is to be sought in practice. The onset of turbulence in a pipe is characterized by the Reynolds numbers reaching a certain value $R = \frac{vdD}{\nu}$, where v is the fluid velocity, d its density, ν its viscosity, and D the diameter of the pipe. Application of this theory to chips in a drill hole would be difficult because of the complicated geometry. However, for a given set of conditions, it can be expected that, R being constant, turbulence will occur at a lower velocity if the viscosity of the fluid is reduced or its density increased. Experiments have borne out this hypothesis.

Laboratory apparatus. In order to observe chips at the bottom of the hole, a clear plastic model was made to simulate the hole bottom. Figs. 1 and 2 illustrate the laboratory apparatus used in these experiments. A 4⅞-in. tricone bit is pictured mounted at the end of a 3¾-in. diameter drill collar. The bit is not rotated. Walls of the hole are simulated by a clear plastic tube 23 in. long and of 5-in. diameter. Bottom is a 1-in. thick clear plastic plate.

Fluid is pumped down the drill collar and returns up through the annulus. A turbine type mud pump shown in Fig. 1 will deliver up to about 130 gallons of water per minute to the model. Flow rates of mud were calculated by diverting the outlet streams from the model to a side tank for a measured interval of time, and measuring the volume of fluid collected.

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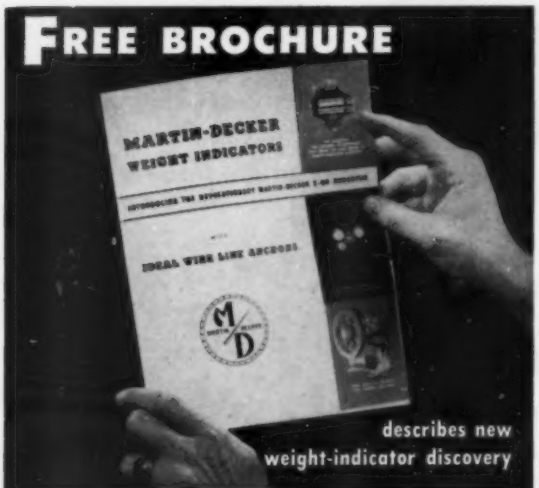

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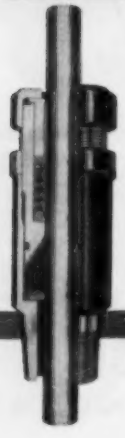

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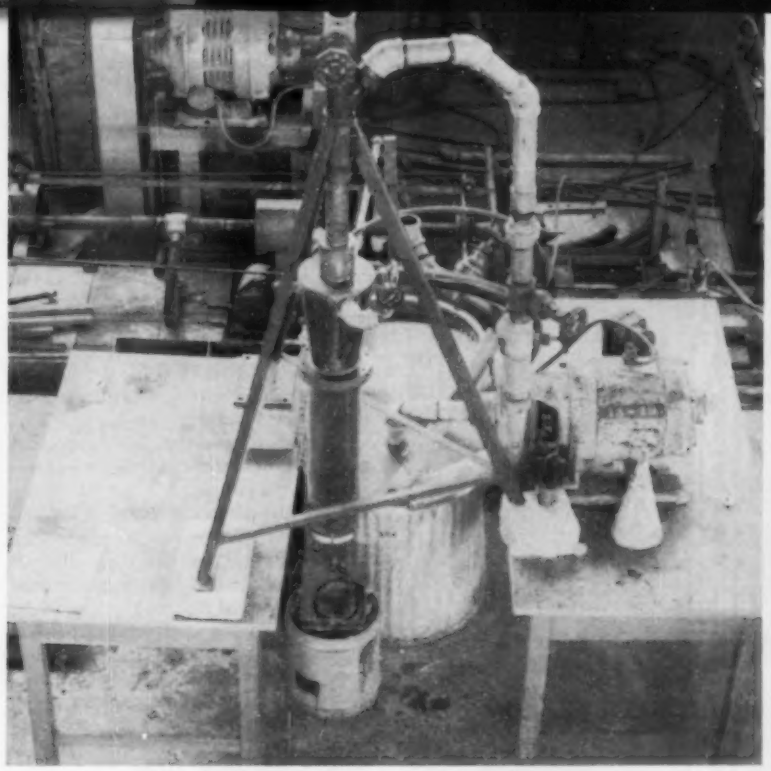
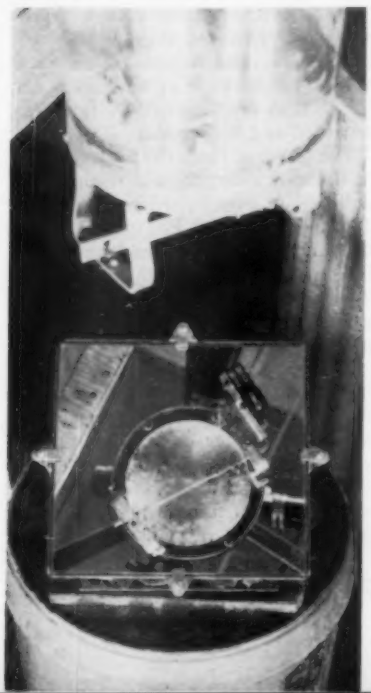


FIG. 1. Apparatus used at Battelle for investigating the chip-clearance action of drilling fluids.

Aluminum pieces .05-in. thick, ¼-in. wide and ⅜-in. long were substituted for rock chips to provide a uniform basis for comparison of results. These dimensions approximate those of rock chips at the moment of their formation by the bit; also, density of aluminum is practically the same as that of limestone. Similarity of behavior of aluminum with rock chips were verified.

FIG. 2. Motion picture studies of chip-clearance action were taken by means of this mirror which reflects light from bottom of plastic chamber.



To prevent the chips from lodging under the bit rollers, the plastic tube was adapted so that it could be rotated manually. It was found that the flow rate of water required to sweep out the aluminum chips fell in a rather narrow range of 25 to 27 gpm. Flow rates of a bentonitic mud of 35 sec viscosity (Marsh funnel) were not significantly different from those for water. This fact corresponds with field experience that drilling rates with water and with light bentonitic mud are not much different.

These experiments showed that the behavior of rectangular aluminum chips pieces in the hole-bottom model is similar to the behavior of actual rock chips, and that the scatter in the data is remarkably less because of the greater uniformity of size and shape of the aluminum pieces. However, the above experiments did not correspond closely enough to the way chips are formed and flushed out in practice to permit answering the question of whether the chips are cleared quickly enough. It seemed desirable at first to establish a definite flow rate, and to simulate the formation of a chip by a rock bit tooth.

A device was added to the model, as shown in Figs. 1 and 2, to accomplish this purpose. Fig. 2 is a view looking into a mirror, of the bottom of the model. Three 1/16-in. rods, extending

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through the bottom and through holes in three aluminum chips, are connected to the cross bar that is visible under the model. When the cross bar is pulled down, the rods are withdrawn from the chips, thereby releasing them.

The three aluminum chips are located at positions from which rock chips would be broken out by the roller bit. At the position of the cross bar corresponding to release of the chips, a microswitch (at right of Fig. 2) is closed by movement of the cross bar. The microswitch actuates a small neon light, which is not shown. This system permits establishing desired rate of flow before releasing and recording the chips, and recording the lighting up the neon timing light and subsequent motion of the chips on moving film. When the frame rate of the moving film is known, examination of the developed film yields data on the time elapsed for each chip from the moment of release until its disappearance into the annular space. All motion pictures of the chips were taken at the rate of 64 frames per second.

Chip-Clearance Time

Two bit designs were used: (1) a standard tricone 4⅞-in. bit with a 1-13/16-in. central fluid orifice (this bit was modified in later tests with air by reducing the diameter of the orifice); and (2) a two-cone, twin-blast 4¾-in. jet bit with two ½-in. diameter nozzles (this bit also was modified later by addition of director tubes to the jet openings, as shown in Fig. 3).

Water versus bentonitic mud. To increase the significance of results, viscosity of the bentonitic mud was maintained at 90 centipoises as measured by the Stormer viscometer. Results for bentonitic mud and for water are summarized in Figs. 4, 5, 6 and 7. In these figures, many of the points lying at the "1000" level on the time scale represent cases when the chips actually remained on the bottom more than 1000/64 seconds. If a chip moved out in less than 1/64 second, the time was recorded as 1/64 second.

For a two or three roller bit rotating at 100 rpm, a chip formed by one roller will be run over by the next roller in 1/5 to 3/10 second. For optimum chip clearance, all chips should be off the bottom within about 1/5 second. For convenience, 10/64 second was chosen for comparison of the several sets of data.

On this basis, flow rates which permit chips to remain on bottom as long as 100/64 to 1000/64 seconds are inadequate, and the drilling rate will be effected adversely. On the other hand, there is no point in providing flow rates that remove all chips in 1/10 second or less, since this will not increase the

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FIG. 3. Modified jet bit was made by adding ½-in. diameter tubes to a two-cone 4¾-in. bit. Tubes are directed at point of contact between teeth and formation.

drilling rate significantly, and such flow rates would require unnecessarily large mud pumps.

Comparison of Figs. 4 and 5 for the standard bit indicates that flow rates required for clearance of all chips within 10/64 seconds are about 50 gpm for water and some value over 120 gpm for the bentonitic mud. Figs. 6 and 7 show that the corresponding rates for the jet bit are 20 gpm and 50 gpm respectively. It may be seen from any of these figures that at the lower flow rates the range of measured time is greater. The scatter of data is an indication that the flow rate is inadequate for chip clearance, and also that turbulence of the fluid is effective in clearing chips.

These figures also indicate the advantage of higher velocity of the fluid stream at the bottom of the hole. Comparing Figs. 4 and 6, and Figs. 5 and 7, an advantage of about 2 to 1 is noted in flow rate for the jet bit over the standard bit. The difference in velocities of fluid at the bottom results partly from the smaller area of the orifices of the jet bit and partly from the fact that chips are shielded differently from the stream in the standard bit with a central hole. The average velocity at the orifice at a given flow rate is 2.8 times greater for the jet bit than for the standard bit, which agrees roughly with the better chip clearance with the jet bit. From the theory of fluid flow, it is expected that the greater speeds will produce greater turbulence under the rollers of the bit, thus moving the chips sooner.

Modified jet bit. To further test the importance of establishing a certain flow velocity at the places where the chips are formed for adequate clearance, a jet bit was modified as shown in Fig. 3. To each opening was welded a tube of ½-in. diameter. These tubes direct the fluid streams toward the positions of chip formation under each roller. Looking at the bit from the bottom, both tubes direct the streams in a clockwise direction. This is considered an important feature, because in the unmodified bit, there are two streams directed downward symmetrically with respect to each roller, so that the two streams produce on the average a nearly zero component of fluid velocity under the rollers perpendicular to the line of teeth. In the modified bit, the two jets on each side of a given roller tend to move the fluid under the roller in the same direction, resulting in an appreciable circumferential fluid velocity under the rollers.

The modified jet bit was tested in bentonitic mud and data on clearance times versus flow rates are presented in Fig. 8. Comparison of Fig. 8 with Fig. 7 shows remarkable improvement in the jet bit effected by the director tubes. The flow rate for a clearance time of 10/64 seconds is 15 to 20 gpm as compared with 55 to 60 gpm for the unmodified bit. Notice also the reduced scatter of the points for the modified bit corresponding to the improved chip clearance. This experiment shows that by proper design of bit hydraulics, it is possible to achieve adequate flow velocities at the places where chips are formed with lower volume rates of flow.

One point not settled by the above experiment is the question of the direction in which the director tubes should point: Toward the leading edges or toward the trailing edges of the rollers? This problem can be resolved better by field tests than by laboratory experiments.

These experiments with water and with bentonitic mud disclose a large difference in chip-clearance characteristics of the two fluids. Since several properties might contribute to the difference, experiments with other fluids were needed in order to learn the relative importance of several factors.

Filtration Rate and Gel Strength

Some drilling experience seems to indicate that penetration rates are reduced when low-water loss fluids are used. Since the bentonitic mud is a low-water loss mud, an attapulgite mud with a very high water-less rate was chosen for comparison. The attapulgite mud was maintained at the same Stormer viscosity, and its gel strength though very high, was lower than that of the bentonitic mud. Initial (zero time) gel strengths corresponded to

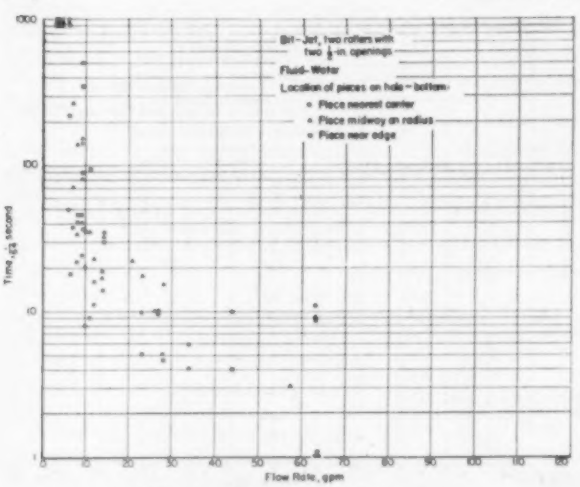

FIG. 4. Chip clearance time versus flow rate for a standard bit in water.

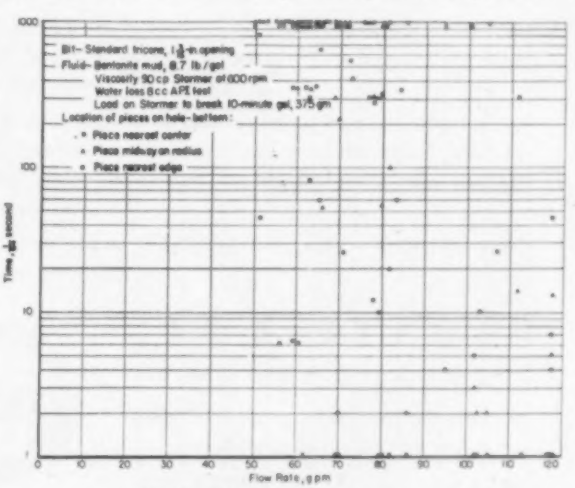
Bit- Standard tricone, 1 ½-in opening
Fluid- Bentonite mud, 8.7 lb/gal
Viscosity 90 cp Stormer at 600 rpm
Water loss 8cc API test
Load on Stormer to break 10-minute gel, 3/5 gm
Location of pieces on hole-bottom:
Place nearest center
Place midway on radius
Place nearest edge
Time, ¼ second
Flow Rate, gpm

FIG. 5. Chip clearance time versus flow rate for a standard bit in bentonitic mud.

loads on the Stormer viscometer of 150 grams and 270 gm, for attapulgite and bentonitic muds, respectively. Tests indicated that the attapulgite mud would clear the chips in 10/64 sec with a flow rate about 25 per cent lower than the rate for bentonitic mud. The difference is not large and may be due to the difference in gel strength rather than to a difference in water loss rates. It was concluded that the filtration rate is not a significant factor in chip clearance.

Effect of Viscosity

Mineral oil was used to investigate the effect of viscosity on clearance time because it is a Newtonian fluid (i.e. not thixotropic), and, therefore, a direct comparison with data obtained with water was possible. Data for the mineral oil indicated that a flow rate of over 110 gpm was required for clearance in 10/64 sec, contrasted to about 50 gpm for water. Mineral oil showed a 20 or 30-gpm advantage over bentonitic mud. This shows the influence of gel strength in increasing the effective viscosity and increasing clearance time. Difference in densities of the mineral oil and the bentonitic mud alone would give an advantage to the mud.

Effect of Density

For Newtonian fluids, the onset of turbulence occurs for a given fluid at a velocity which depends on the density and viscosity of the fluid and the geometry of the vessel. Since the densities of fluids already tested covered only a narrow range, an attempt was made to obtain a more significant test for the effect of density.

A bentonite-barite mud with its Stormer viscosity adjusted to 90 centipoises was observed. Initial gel strength on the Stormer viscometer required a load of 160 gm, and after 10 minutes, a load of 230 gpm. Motion pictures could not be taken because the barite mud was too opaque. Data were obtained by establishing a given flow rate, then releasing the chips and stopping the pump 5 seconds after release of the chips. The number of chips remaining in the model was recorded and the experiment repeated for other flow rates.

Using the standard bit, it was found that the minimum flow rates which would clear the three chips on most trials with 5 seconds were: For mineral oil, 53 gpm; for attapulgite mud, 65 gpm; for bentonitic mud, 80 gpm; for water, 30 gpm; and for the barite mud, 40 gpm. Since the gel strength of the barite was nearest to that of the attapulgite mud, this comparison was most significant and shows that indeed the greater density of the fluid reduces the flow rate for clearance in a given time, just as would lower viscosity.

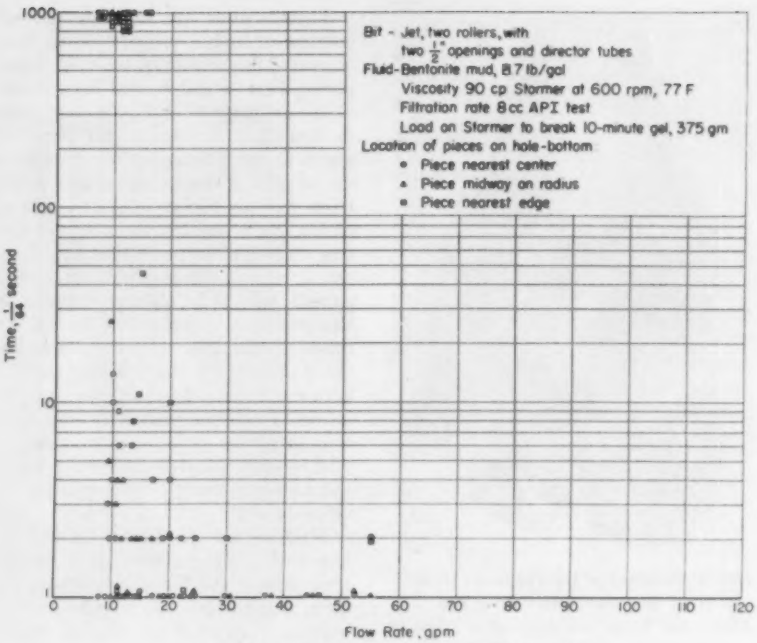
Bit - Jet, two rollers, with
two 1/2" openings and director tubes
Fluid - Bentonite mud, 8.7 lb/gal
Viscosity 90 cp Stormer at 600 rpm, 77 F
Filtration rate 8 cc API test
Load on Stormer to break 10-minute gel, 375 gm
Location of pieces on hole-bottom
Piece nearest center
Piece midway on radius
Piece nearest edge
Time, 1/64 second
Flow Rate, gpm

FIG. 8. Chip clearance time versus flow rate for the modified jet bit in bentonitic mud.

Clearance of Small Chips

All data reported so far on the clearance of aluminum chips were obtained with chips of one size, roughly that size which would result from the action of the cutter teeth on rock. It might be assumed that smaller chips will be removed from the bottom at least as quickly as the larger chips will be removed. This assumption was verified experimentally.

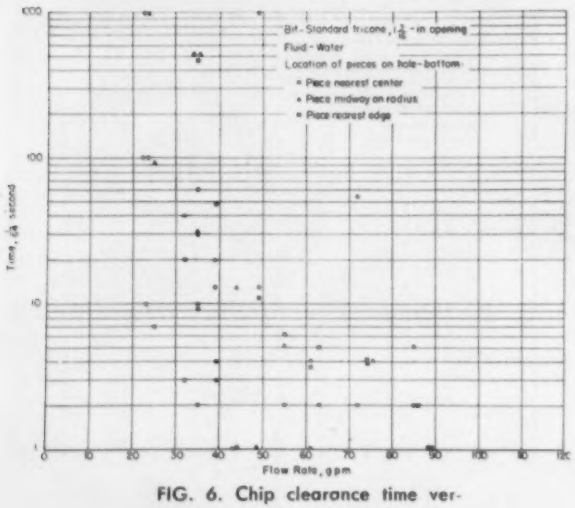
Bit - Standard tricone, 1/16 - in opening
Fluid - Water
Location of pieces on hole-bottom
Piece nearest center
Piece midway on radius
Piece nearest edge
Time, 1/64 second
Flow Rate, gpm

FIG. 6. Chip clearance time versus flow rate for a jet bit in water.

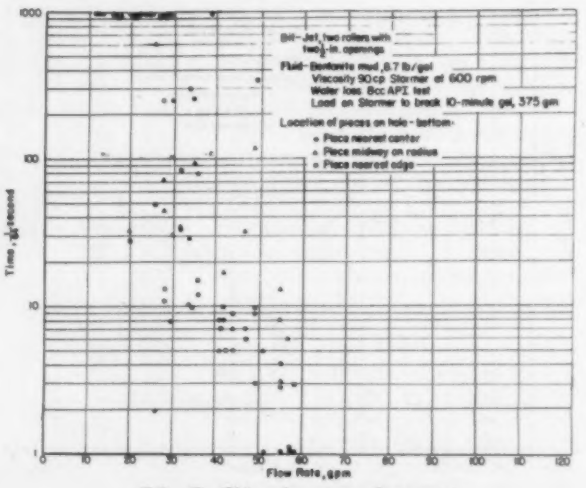
Bit - Jet, two rollers with
two 1/2 - in. openings
Fluid - Bentonite mud, 8.7 lb/gal
Viscosity 90 cp Stormer at 600 rpm
Water loss 8cc API test
Load on Stormer to break 10-minute gel, 375 gm
Location of pieces on hole-bottom
Piece nearest center
Piece midway on radius
Piece nearest edge
Time, 1/64 second
Flow Rate, gpm

FIG. 7. Chip clearance time versus flow rate for a jet bit in bentonitic mud.

Clearance by Air

Since air and natural gas have come to be used as flushing fluids in oil well drilling and often with remarkable penetration rates, the clearance times for air were measured in the model. Experimental equipment was modified only in the substitution of a high-pressure air line for the turbine mud pump. An orifice meter, with appropriate pressure gages, furnished data for calculation of flow rates.

Experiments with the modified jet bit and large aluminum chips showed that most of the chips are removed in 1/10 second by a flow of 100 cfm (free air), and that rates up to 250 cfm do not significantly reduce the clearance times.

The standard bit, with a 1-3/16-in. diameter orifice, required an air flow rate in excess of 235 cfm to remove most chips in 1/10 second. When the diameter of the orifice was reduced to ¾ in., a flow rate of 190 cfm was sufficient for clearance in 1/10 second.

It was apparent from these measurements that hydraulic design of the bit is as important for air as it is for a liquid, and that the modified jet bit is superior to the standard bit as far as air-volume rates are concerned. The experiments showed that, with the modified jet bit, it is possible to clear the chips from the bottom at flow rates which are not sufficient to carry the chips out of the hole. Here again, it might be possible to bypass some flow through orifices above the bit, in such a way that the velocity requirements at the bottom and in the annulus would be met with the minimum compressor expense.

Hardness Reducers

Extensive research has been carried on and reported by Russian authors on the effects of minor concentrations of electrolytes and of organic surface-active substances on the drilling strength of rock. The Russian report covers the theory of a physical-chemical basis for effect, laboratory methods of determining properties of hardness reducers, a discussion of appropriate substances to be used on different kinds of rocks and the best conditions of their use and field problems, including the effects of hardness reducers on the properties of clay solutions. There is also a large compilation of data on hardness reducers obtained in the field and in the laboratory. On the average, increases in drilling rates of the order of 30 to 60 per cent are attributed to the use of hardness reducers.

Action of hardness reducers in minute cracks or microcracks appears to be twofold: Reduction of free surface energy by absorption, and binding a film of water to the surfaces of the microcracks. The microcracks tend to heal themselves after the load on the tool is released, but the film of water in the crack requires time to flow out, the rate being lower the more tightly bound the film. Therefore, if the succeeding impact of the tool occurs soon enough that a given crack is still open appreciably, a chip will be produced more easily.

The Russian report was spot checked at Battelle.

One series of tests included the use of a flat chisel on Indiana limestone. Two such experiments carried out with a .07 per cent solution of sodium hydroxide showed that 22 per cent more rock was broken where the solution was used than was broken where distilled water was used. The concentration of sodium hydroxide was doubled, and two such tests yielded benefits 20 to 60 per cent as great as cited above for the optimum concentration.

Drop-test data for wet and dry rock further support the hardness-reducer theory. According to theory, the adsorption of any substance, including water, to the surfaces of the microcracks will reduce the free surface energy and result in reduced hardness. This might seem to contradict the ob-

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servation that drilling rates with air as the flushing fluid are generally greater. However, better chip clearance with air under usual operating conditions may account for the greater drilling rates. Also, since the relationships between hydrostatic pressure and the strength of the rock are not fully understood, part of the explanation for the improved performance when air is used may be found in the fact that the hydrostatic pressure on bottom is so small.

Although these experiments only "scratch the surface" on the subject of hardness reducers, they have confirmed the basic claim of the Russian report — that exceedingly small concentrations of specific reagents can effectively reduce the hardness of rock, thereby leading to the possibility of increased drilling rates.

Concluding Remarks

Results and conclusions of this research indicate quite clearly what are most likely to be profitable avenues toward increased penetration rates. Experiments with the drop tester showed that a large fraction of the power can be dissipated in regrinding chips, and the experiments with the model have shown what factors are important in clearing the debris quickly. It has also been shown that careful control of the chemical composition of the fluid can result in greater peneration rates.

Application in practice. Magnitudes of the effects of viscosity and density on chip-clearance times were compared on the basis of equal volume flow rates. Data have shown large differences in the clearance times for a given flow rate of water and other drilling fluids, largely caused by differences in viscosity, gel strength and density. In practice, clearance times probably should be compared for a given mud pump power, which results in significantly lower volume flow rates for the more viscous and more dense fluids. For this reason, the difference in chip-clearance effectiveness between water and other fluids is expected to be greater in practice than might be surmised at first from data in this report.

From another viewpoint, the practical possibilities of improving chip clearance by carrying effective viscosity and density are limited by several factors. Increases in fluid density in order to achieve better clearance times would result in lower pumping rates for a limited pump power, thus defeating the purpose to some extent; however, the amount of increase in density is usually limited by allowable pressure in the hole and by the expense of the weighting material. In contrast with these limitations, effective viscosity (determined, in part, by gel strength) can be varied over a relatively much wider range, probably being limited most often in practice by the need for a fluid with a low filtration rate. Thus, it is apparent that, although filtration rate does not **directly** affect clearance times significantly, difficulty of achieving a very low water-loss rate in a fluid of low viscosity poses a problem in mud formulation.

Design of bits with improved hydraulic systems for better chip clearance will immediately involve problems in metallurgy and stress analysis. Any changes probably will be a compromise between the ideal hydraulic system for optimum chip clearance and a long-lived bit yielding maximum drilled hole per dollar.

Feasibility of increasing penetration rates significantly by using chemical hardness reducers will depend on the added cost of materials, equipment, and technical help to maintain the necessary concentrations of chemical in solution. Although new research findings might change the picture any time, the Russian report indicates that benefits in increased penetration rate would range up to a maximum of 30 to 60 per cent. These benefits must be weighed against the costs and the complications of the mud program which may arise. ★ ★ ★

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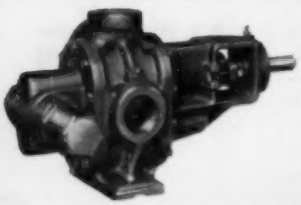

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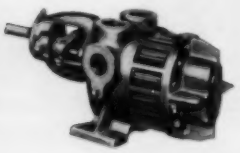

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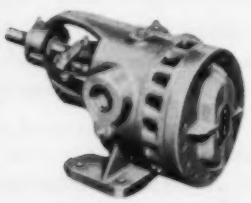

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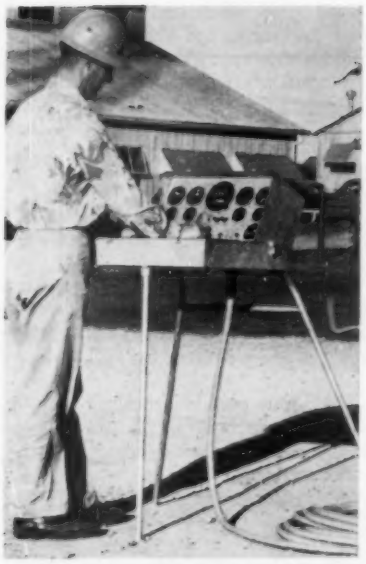
Overall view of remote controlled pumper. Engine is located in the hooded compartment behind the truck cab.

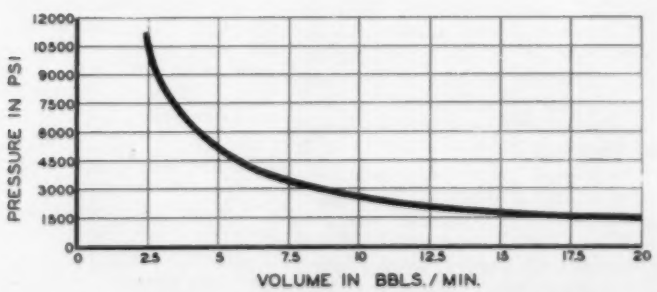


A unique feature is the remote control system. Unit can be operated from a point 125 feet from the truck.

HEART of a new high horsepower pump truck recently placed in the field is a 12-cylinder 1500 horsepower aircraft engine which may be remotely controlled by the operator in well acidizing and fracture treatments. It is reported that the unique system of controlling the unit from an instrument panel 125 feet from the truck is used for the first time on well treating equipment. The unit is capable of handling pressures up to 10,000 psi and of injection rates up to 20 barrels per min.

The remote control system permits the service engineer or pump operator to perform all necessary pump operating functions from a point where he may observe other equipment used in the treating operation. Easy to read indicators on the control panel provide information on the operating condition of the engine and pump as well as the pump pressures and discharge rates. The unit is equipped with automatic safety controls which shut down the unit if operating pressure limits are exceeded. Another interesting safety feature is a fire control system operated from the control panel. The engine is completely hooded to reduce the possibility of oil spray reaching the engine. By pressing a button at the remote station, the complete engine space is flooded with CO_2 gas in a matter of seconds.

The aircraft engine used on the unit has maximum intermittent horsepower rating of 1500 hp and a continuous rating of 1100 hp. Tests on the unit have indicated an overall efficiency of approximately 73 per cent and a continuous hydraulic horsepower rating of 600 hp. Pumping capacity ranges from 2.5 bbl per minute at 10,000 psi to 20 bbl per minute at 1500 psi depending upon the power frame and pump head used. A torque converter drive is used on the unit for smooth operation over a wide range of pressures. ☆ ★ ★



Capacity of pump unit at various injection pressures. Wide range is made possible by changing the power frame and pump heads.

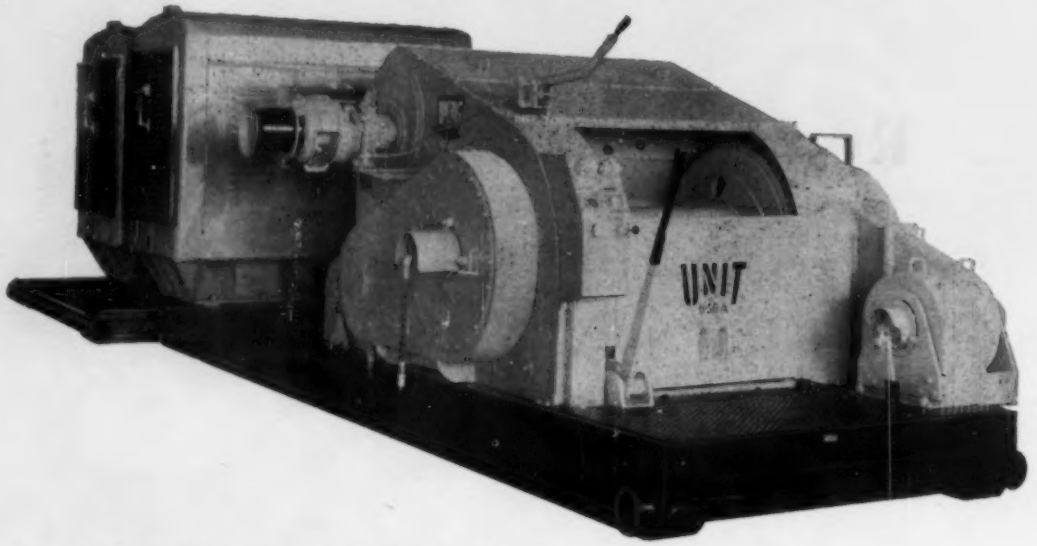


Photo of U-36-A Draw Works, from Driller's side.

Unit Rig Introduces a New Shallow-to-Medium Depth Draw Works

The U-36-A designed for drilling depths requiring a range of 300 to 500 HP

The new U-36-A meets the requirements of drilling contractors who need flexibility and simplicity of operation in a shallow to medium depth draw works. This newest Unit Rig draw works is rated conservatively for maximum input horsepower of 500. However, this flexible unit can be used economically with less power for drilling in areas where the maximum input horsepower is not required. In fact, the unit may be used efficiently for drilling any depth requiring a horsepower range of 300 to 500.

The U-36-A is designed to be transported as a single package in the field or it can be separated into two packages for highway moves. With a single or two-engine unit, the compound and engines are mounted on a common skid and are moved as an integral unit. This construction insures engine alignment at all times.

Simplified design . . . Unit Rig engineers have incorporated several unique features in the design of the U-36-A. It was their desire to produce a rig that would fill a need for maximum performance with the minimum of parts. For instance, the use of an air clutch for the catshaft drive eliminates the necessity for an inertia brake. On the double-drum model this catshaft air clutch also allows the use of a positive clutch on the sand reel and eliminates the introduction of air through the cathead. The simplified control panel consists of only four air valves.

Fawick Ventorque 24" VC 650 clutches are used for high and low drum clutches. This application gives a high degree of interchangeability. The air space between friction surface and operating tube on the VC type clutch insures maximum cooling at all times. The torque is transmitted through steel pins, thus relieving the tube from torsional loading.

Extra large drum . . . The U-36-A has an extra large drum (18" diameter x 46" long barrel) which provides less than three wrap spooling when hoisting 90 foot stands with a six line reaving system, and has Lebus grooving for 1⅛" wire line.

Incorporated with the large drum are self-energized, equalized, single point adjusted mechanical brakes. The brake rims are 44" diameter by 10" wide.

The highly portable, compact U-36-A is available in both single and double-drum models, and either model can be trailer mounted.

Special features . . . The U-36-A has Unit Rig fully enclosed water circulating brake rims of forged alloy steel, for maximum service life. The 15" double hydromatic brake is of the high speed, built-in type with automatic clutch.

The low or high clutch control valve also operates throttles. Therefore the engine is always at idling speed when clutches are engaged. Both low and high clutches can be serviced without shaft removal.

Other important features of the U-36-A are: emergency locking pins for low drum and catshaft drive clutches; large diameter, alloy steel shafts with short center distance between main load bearings; independent torque converters for each engine; oil-tight cases; and

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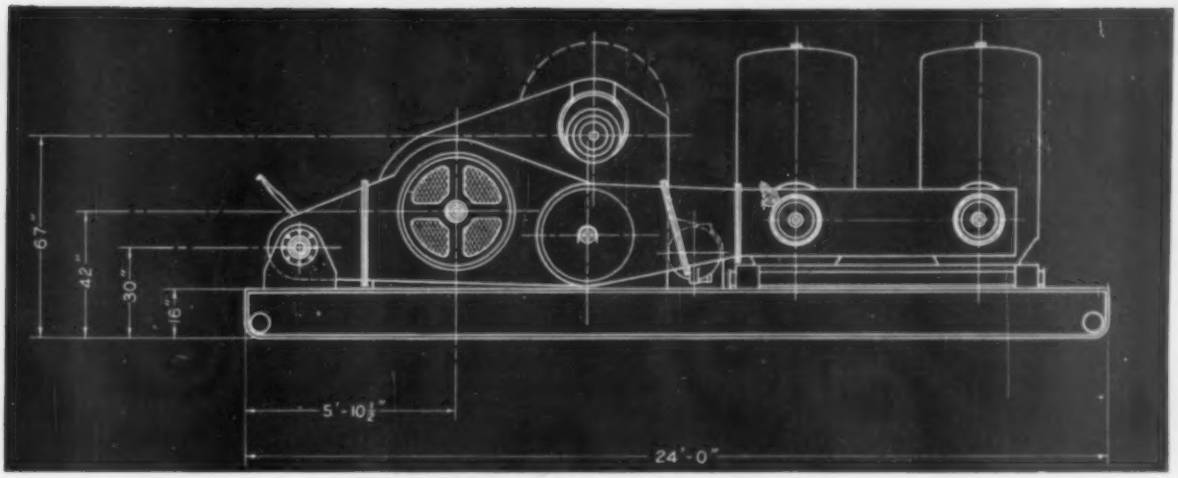

U-36-A Dimensional Layout — Side Elevation.

pressure lubricating system.

The main skid is 24' long, by 6' 8" wide. The skid beams are 16" x 8½" for minimum deflection with minimum weight. The width of the draw works is 9' 3¼", and stands 7' 2½" high, less sand reel.

The U-36-A has been in the making for over a year. The first unit was not put in the field until Unit Rig engineers had been satisfied that their main objectives — rugged dependability and simplified operation — had been accomplished. Incorporated in the unit are the simplicity of the popular U-34 and the ruggedness and dependability of the new U-1220.

Complete information on the new U-36-A may be obtained from the following supply stores: American Pipe & Supply Co., Bovaird Supply Company, Houston Oil Field Material Company, Industrial Supply Company, Iverson Supply Company, Lucey Products Corporation, Mid-Continent Supply Company, Norvell-Wilder Supply Company, The Republic Supply Company of California; or direct from Unit Rig & Equipment Co., Tulsa, Oklahoma. Export sales are handled by Mid-Continent Supply Company, 45 Rockefeller Plaza, New York 20, N. Y.

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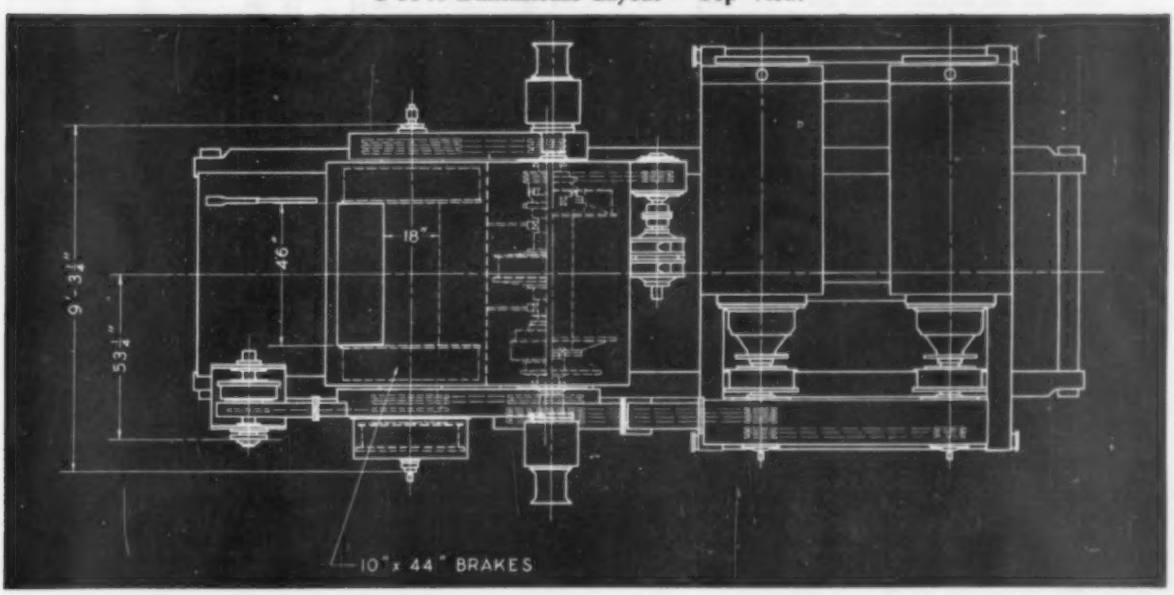
High Drum Drive	1½" Double
Low Drum Drive	1½" Triple
Input	1¼" Quad
Catshaft — Sand Line	2" Single
Hydrotarder	1¼" Triple
Rotary Countershaft	1½" Single

Speed Ratio Factor between High and Low — 2.7:1

U-36-A Dimensional Layout — Top View.



Radioactivity Method Evaluates Rust Coatings

Fish-oil based protective coating traced through rust to bare metal

RADIOACTIVE tracing techniques were developed during three years of research at Battelle Memorial Institute at Columbus, Ohio, to measure the penetration of fish-oil based protective coating through rust to bare metal. The idea was developed when researchers found that X-ray techniques were not successful. The radioactive technique was developed in five stages:

1. Identify one or more of the major chemical constituents in the fish-oil based vehicle of the coating.

2. Synthesize this constituent using radioactive carbon-14 (C^{14}).

3. Add the C^{14} constituent to the fish-oil based vehicle making it radioactive.

4. Apply the radioactive rust coating to the surface of rusted test panels and allow to dry for two weeks.

5. Shave off the surface of the test panels at 0.5 mil intervals and measure radioactivity at each level down to bare metal.

Major Component. It was found that a major component common to all fish oils is glycerol in the form of triglycerides. The glycerol portion of the fish oil was then replaced by carbon-14 labeled glycerol. This was done by obtaining the fish oil fatty acids by saponification of the fish oil, followed by re-esterification of these fatty acids with carbon-14 labeled glycerol, thereby making a radioactive reconstituted fish oil.

Radioactive Coating Tested. Extensive testing and evaluation was necessary to establish that the reconstituted fish oil was identical in every way to the original oil. In addition to months of laboratory testing, exhaustive tests were conducted in weatherometers and in the extremes of atmosphere exposure areas throughout the country to be certain that the synthetic procedures used in the research to radioactivate the fish oil did not change characteristics of the coating.

After more than a year of testing the radioactivated coating to insure its performance, evaluation in the laboratory was made.

Preparation of Specimens. Several rusted steel disks, 1 in. in diameter (1/16-in. and 1/32-in. thick) were wire-brushed and coated with the radio-activated material. The coated specimens were allowed to dry in the laboratory for approximately two weeks.

Lapping Procedure. A specimen was mounted in a lapping fixture that made possible controlled removal of the surface layer in extremely small increments. Crocus cloth was used as an abrasive. Micrometer measurements were made before and after each lapping cycle to determine the exact thickness of the layer removed.

Radioactivity Measurement. Measurements of the specimen surface were made with both an end-window Geiger-Mueller tube and with a gas-flow proportional counter. Because of the low energy of the beta particles emitted by carbon-14, this radiation is readily absorbed by matter. The beta particle

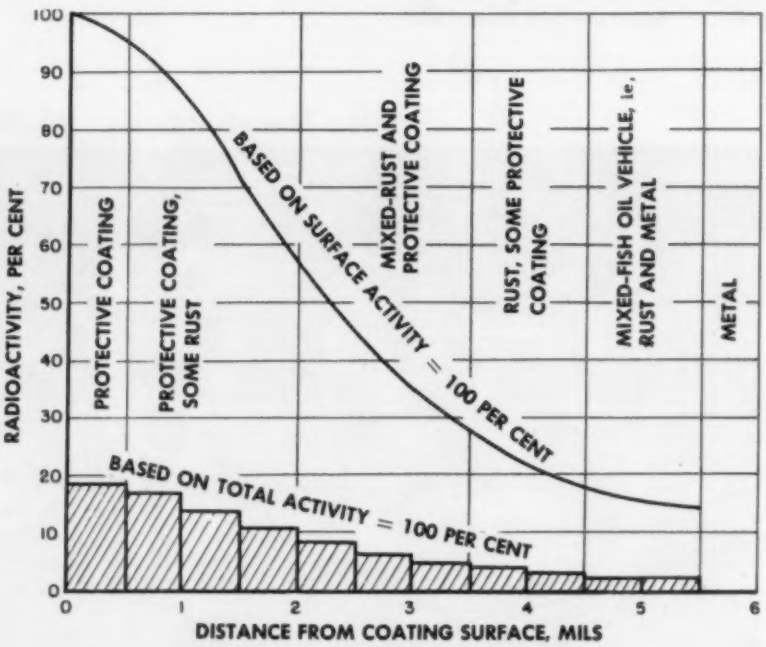


FIG. 1. Composite curve of radioactivity vs distance from coating surface for several specimens. Bar graph shows per cent radioactivity for each 0.5-mil layer.

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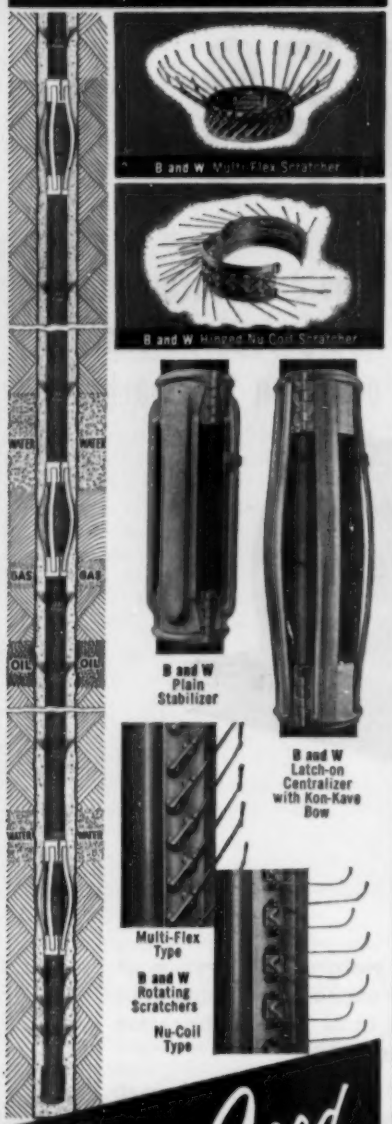

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range in the coating film is approximately 2 mils. Since it was desirable to measure the radioactivity of a 0.5-mil thick surface layer, the measurement with a Geiger-Mueller tube was found suitable.

With this detector, only the most energetic beta particles emitted from the upper layer of the coating and rust film were measured. As the coating and rust layer were removed by lapping, the residual radioactivity decreased and the precision of measurement with the Geiger-Mueller tube also decreased.

It became necessary to use a gas-flow proportional counter to verify the presence of the radioactive component in layers near the bare steel surface where radioactivity was relatively low. When using this counter, the specimen was inserted directly into the radioactivity detector, and all beta particles emitted from the coating and rust surface were counted.

Results of Measurement. Fig. 1 is a composite curve of the radioactivity vs distance from coating surface for several specimens. These specimens were most nearly comparable in metal and protective-coating film thickness. The per cent of radioactivity of each 0.5-mil layer is shown in bar-graph form. This percentage is based on the total activity of the protective coating-rust layer. These values were obtained by graphical integration of the composite radioactivity vs distance from protective coating-surface curve.

Fig. 1 indicates a moderate decrease of radioactivity, and hence fish oil-vehicle concentration through the coating and rust film. As the metal surface was approached, a leveling off of the concentration was observed. At the metal surface, where no rust was observed, no radioactivity was detected. Within 0.5 mil of the bare metal surface, approximately 3 per cent of the total fish-oil vehicle was found. Precision of the radioactivity measurements with a Geiger-Mueller tube in this layer was poor. Measurements with the gas-flow proportional counter in this region, however, verified the presence of sufficient radioactive fish-oil vehicle to substantiate the data obtained with the Geiger-Mueller counter. As long as some rust could be observed on the surface of the metal, the gas-flow proportional counter detected a measurable amount of radioactivity.

Acknowledgment

Material presented here is based on a 30-page report prepared by the Battelle Memorial Institute summarizing three years' research for the Rust-Oleum Corporation of Evanston, Illinois.

* * *

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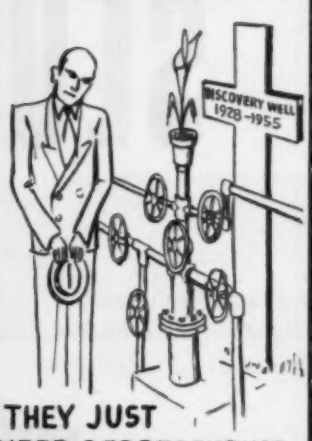

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REQUIREMENTS FOR DRILLING CONTRACTORS

Gene Graham*

OIL well drilling is a highly technical business and requires a special type of experience, background and know-how for success. But allowing the necessary know-how, success in this line still requires a sizable stake, even when undertaken on a modest scale. The first requirement, therefore, for the drilling contractor is financial responsibility.

Oil well drilling is also a hazardous business in all its aspects, and anyone who ventures into it must be prepared to weather substantial losses that go with the characteristic risks that must be provided for. These include every sort of contingency from bidding too low, to the cost of a long fishing job which could ruin anyone financially unprepared to meet it. In addition, the investment in each rig and its accessory equipment is so high that a crippling loss can result if too great a percentage of a company's rigs are idle for too long. The investment in a drilling rig usually runs from $300,000 to $550,000. The volume of necessary equipment may be gathered from the following list needed to drill a 10,000-ft well:

1. **The rig itself; consisting of a drawworks, engines, mud-pumps, water-pumps, a derrick running up over one hundred feet, as well as trucks, bulldozers, accessory machinery and tools.**
2. **10,000 to 12,000 ft of drill pipe.**
3. **12,000 ft of steel casing.**
4. **50 to 100 drilling bits.**
5. **500 to 1000 tons of drilling mud and additives.**
6. **2000 to 5000 sacks of cement.**
7. **48,000 bbl of water with 300 bbl of fuel oil.**

Some of these items may be supplied by the client, if the contract so specifies, but they are part of the equipment in any case.

From the foregoing, it is apparent that the oil well drilling contracting business is not safe territory for anyone with only a shoestring for capital. There are those who try it, however, and when the conditions and the luck are with them, many small operators succeed and build up substantial businesses.

Know-How Required

Supposing that the would-be contractor has satisfied the financial requirements for entering the business, the next essential for success is *know-how*... and a reputation for having it; in other words, a standing with the oil companies, and with independent operators, who have wells to be drilled. The confidence of the client's technical personnel, particularly the drilling superintendent, is not a must, but it helps when contracts are being awarded. These technicians know the business and are quick to detect any lack of experience and competence in a contractor or his employee.

How is such know-how acquired? A good percentage of successful drilling contractors acquire their know-how by working on drilling rigs, starting at the bottom as rotary helpers, or "roughnecks" and working up through cathead-man, derrickman, and driller until they become "toolpushers" or foremen, having charge of three crews which operate the rig on a 24-hour basis.

The toolpusher, like the contractor he may aspire to become, must know every job on the rig, besides being a competent buyer of materials and supplies, a leader with the ability to meet emergencies of every kind from failure of the machinery, loss of mud circulation, a bit stuck in the hole or a fishing job, to fire-fighting and first aid to an injured workman. When he gets to be a foreman, he knows how to handle all these contingencies and is equipped, at least in that respect, to enter the contracting business, if so inclined, when he has the financial resources.

Legal Considerations

Finances and know-how being accounted for properly, there are some legal considerations which must be observed in entering the business, but they are usually routine. As an example, there is no law in California which requires a drilling contractor to have a license to operate, but without one he has no legal status in a court of law in connection with his business. He would therefore be risking his capital without redress in case of legal action or a bad debt. The prospective contractor should therefore take the state examination if it is part of the procedure and obtain a license as part of his preparations. A knowledge of workman's compensation laws should also be a part of the contractor's equipment for entering the business if only to keep out of trouble.

Field Rules

There are field rules governing the drilling of oil wells which are also part of the laws governing property, leases, oil and mineral rights, the conservation of natural resources, and similar considerations; but these are mainly the concern of the petroleum operator who employs the contractor.

Minute specifications govern the process of drilling a well, and the contractor follows directions based upon previous surveys of the geological formations which have already been made for the petroleum operator. Such surveys are to minimize the chances of failure, which in the case of unproven fields, are about 9 to 1—a long-shot gamble with big money which can hardly be equalled. In sum, the contractor estimates the job according to figures based on his previous experience in drilling many wells, on his knowledge of his own costs for daily operation, and on a careful study of the formations through which he is expected to drill.

If, for example, he runs into a difficult formation where faulting underground may change the picture set-up in the geological survey, it may take weeks to get through one stratum for which the estimate only allowed a few days. If he has the bad luck to drop a string of tools in the hole, he may have a fishing job on his hands at a cost of about $1500 per day.

If the contractor is not financially prepared to weather setbacks of this nature, and prepared by experience to make up for such losses with extra profits when the going is good, he must eventually find himself out of business.

Working in the Wilderness

The search for oil quite often leads to places where nobody would ever go from choice, and which requires tre-

*Executive vice president, Thomas P. Pike Drilling Company.

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mendous resourcefulness and added equipment to even reach with the drilling rig and accessory materials. One job which Thomas P. Pipe Drilling Company undertook about three years ago for Petroleos Mexicanos was in the wilds of Lower California, about 800 miles south of the border. The drilling rig had to be transported on barges down the Pacific Coast in the open sea and landed on a beach with no docking facilities. The drill site was 12 miles inland from the landing place, so earth-moving machines and other road machinery had to be shipped down the coast to build the 25 miles of road actually required to reach the drill site. Once there, some lighter supplies were flown in with DC-3's, but three different landing fields had to be built before the runways were adequate and safe for these large planes.

A camp had to be set up for 60 people, including officials of the Mexican Government Petroleum Authority, Pemex, and all this required the service of a commissary firm brought in from the United States.

There was no water in the immediate area, and a tank truck had to shuttle back and forth 24 hours a day between the camp and a ranch nine miles away, in order to keep the rig going and the personnel supplied.

Then there was the cost of extra insurance which exceeded $12,000, while transporting the equipment, plus the difficulties caused by delays on the American side of the border whenever equipment had to be flown to and from Los Angeles for repairs.

This one case demonstrates the extreme and varied financial hazards which the drilling contractor must be prepared to face. Offshore drilling and the discovery of oil under swamplands now offer new challenges for the contractor in getting to the drill site when he gets a job and operating his rig after he reaches it.

Problems of Personnel

Obtaining and keeping qualified personnel is always a problem in the oil well drilling business, and most of the difficulty is due to the nature of the business and the remote territory in which it so often operates. The few factors discussed below will suffice to give the reader a general picture of the situation.

1. **LOCATION.** Drilling jobs in new fields, or in remote areas, present conditions for employees which are not attractive to men with families. Rigs are constantly changing locations and seldom can the oil well drilling worker settle down for long in a location where there are schools, shopping centers, amusements and other attractions. Living accommodations are consequently not the type that a well-paid workman would care to consider as permanent.

2. **TRANSIENTS.** A good percentage of those who apply for this work, therefore, are transients, with all the problems that this class of labor implies.

When the Cuyama oil field was first opened in California, Richfield Oil Corporation was obliged to build an airstrip and fly in crews from Bakersfield daily. This was expensive, unsatisfactory and obviously a temporary arrangement. Once the extent of the field and its probable life was established, the company found it good business and good industrial relations to design and build a model town from scratch. There a permanent class of employees has settled down, bought homes and are rearing families in the decent surroundings which Americans expect. This is an unusual case, however, and in the majority of fields it might be impractical, hence the transient nature of the workers and the consequent labor turnover.

3. **WORKING HOURS.** The working hours and the shifting schedules also tend to discourage many desirable employees who might otherwise be available. Each drilling crew of five men works seven days, and in California they take two off before moving forward to the next later tour or shift, which carries the crews around the 24-hour cycle of three 8-hour tours to fill the working day. Extra pay is given for the late shift, but the night work is not attractive to many.

4. **ACCIDENTS.** Finally, the accident ratio deters some workers from remaining in oilfield work. Safety programs are a part of every contractor's management system and the insurance premiums are a large item in the cost of doing business, but the accident ratio continues high in most cases, and men with families often prefer to work in safer territory.

Provision to attract competent help in spite of these drawbacks is therefore an essential part of the preparations for entering this field.

Getting Contracts

Finally, when the prospective contractor has qualified for entry into the oil well drilling business by obtaining adequate financial backing, complete know-how of drilling procedures, and dependable sources of operating personnel, he only needs to have drilling contracts which will pay him a profit. If he has the background of a toolpusher, or one of his employees has, he should be properly equipped to estimate from specifications furnished whenever he is invited to bid on jobs.

Competition is keen in any contracting business, but the most dangerous competition comes from the marginal operators whose experience is insufficient for correct estimating, or who are prone to take jobs at a very low figure in order to remain in business. The successful contractor will know when to bow out if such practicioners force prices below the profitable level. He will confine his bidding to the many operators who are ready to pay a fair price to a drilling firm in which they have confidence.

Estimating requires the study of reports on formations below the drill sites, examination of logs of previous wells drilled in the immediate vicinity and other data. Estimates are then based on the average rate at which drilling can safely be expected to proceed for that particular hole. Even then, there will be risks, since the possibility of an unknown fault below the drill site may change the formations from easy going to strata very difficult to penetrate, with a resultant loss of time and money. Other important considerations which call for sound judgment when estimating a job are: Location of the nearest company rig and the cost of moving it; availability of the rig in time for the next job; type of terrain and accessibility of the drill site; how much private road must be built to get the equipment to it; sources of water and many other vital items.

Bids based on all the available information such as the above, and carefully estimated, should get the competent contractor a fair share of the available business. As he becomes better known, a reputation for integrity and reliability among the operators should get him an even larger share.

The Future

There is currently a definite trend toward deeper wells as oil is discovered at lower levels. Some of the discoveries are beneath old fields which were thought to have been exhausted. These furnish new sources of drilling contracts, but drilling to the greater depths calls for advanced methods and equipment capable of handling the weight of three and four miles of drill pipe.

If the contractor wants a share of this business he must constantly keep abreast of the requirements to handle it. In addition, as stated at the beginning, he must so conduct his affairs as to be prepared to take losses, or even a series of them. The whole business is a gamble for huge stakes, but those who survive the hazards have a good chance of financial success.

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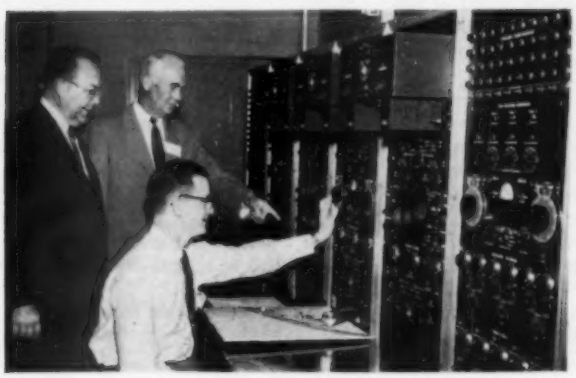
SUN OIL COMPANY'S new Production Research and Development Laboratory at Richardson, Texas, near Dallas, was dedicated December 7. At right is laboratory proper, an air-conditioned building taking in approximately 20,000 sq ft. The service building, left, is separate but is connected to the laboratory by a covered walkway. It has 10,000 sq ft of floor space. Both structures are one-story high, with steel frame and masonry construction. There is ample ground for expansion of facilities when needed.

Toward More Research

The fine buildings and excellent equipment at Sun Oil Company's new Production Research and Development Laboratory at Richardson, Texas, is another evidence of the company's belief in greater research. The industry turns more and more toward research to solve baffling operation problems.

MANAGERS OF DEPARTMENTS at Sun's new laboratory meet in the library. They are: Preston E. Chaney, assistant director, Production Research and Development; I. B. Hamilton, Geological Service; F. L. Johnson, director; Dr. R. J. Cordell, Geological Research; and Morris Bock, Production Service.

F. L. JOHNSON (left), director of Production Research and Development, and Jno. G. Pew, watch as Granville Dutton operates Sun Oil Company's high-speed electronic analyzer at the company's new laboratory. Developed and constructed by Sun researchers, it is used to calculate oil and gas reservoir behavior under varying production schedules.



ENTRANCE TO THE SUN LABORATORY. Activities at this site will include research programs in geology and geophysics, reservoir mechanics, and production technology. The laboratory also will serve as headquarters for two groups supplying general services to the operating departments.

JONATHAN G. PEW of Philadelphia, below, vice president in charge of production for Sun Oil Company, delivers the speech of dedication. At the speakers' table are: R. V. Thompson, mayor of Richardson, who gave the speech of welcome; Sam Gladney, Sun's Southwest Division manager, who presided; and F. L. Johnson, director.

EXPLORATION ACTIVITIES

MONTANA

Union Oil Company has made a new discovery in the eastern portion of the Cut Bank field. The well, Coughlin 1, is producing at the rate of 460 barrels per day of 36 deg oil from Madison limestone at about 2000 ft. Hitherto, the surrounding East Cut Bank field has been primarily productive of gas from the Cut Bank sands.

WYOMING

★ Skelly Oil is testing its No. 1 Government-Williams, one mile south of Black Mountain in the East Blue Springs area of Hot Springs County. The Phosphoria was perforated in three intervals between 3090 and 3130 ft. On the first 7½-hour test, 23 bbl of oil and 71 bbl of oil-cut mud was recovered; there was no water.

CALIFORNIA

★ Union Oil Company's Union Sugar 37 wildcat, south of the Guadalupe field in Santa Barbara County, has been tested on the pump at rates between 75 and 100 bbl per day of 13 deg crude. A significant feature of this discovery is that it is in Miocene shale and sand not productive in the Guadalupe field to the north.

★ The Texas Company has completed and shut in its Benamati No. 1 wildcat in Glenn County, after the well flowed at the rate of 4,400,000 cu ft of gas daily from intervals between 3532 and 3558 ft.

★ Richfield Oil Corporation is preparing to drill an offshore well about 2600 ft off Pita Point, five miles west of Ventura. The company is installing special drilling equipment on an exploration boat from which the well will be drilled.

★ Continental Oil Company has acquired a 50 per cent interest in Merchant Petroleum Company's Alhambra-Monterey Park townlot lease in Los Angeles County, the two are preparing to drill a joint wildcat. The residential leases in the block now aggregate 450 acres, including 1000 residential lots. The wildcat will be known as Continental-Merchants-Monterey Park Unit No. 1 and will be on a one-acre drill site near intersection of Hellman Avenue and Atlantic Boulevard.

★ Signal Oil & Gas Company is preparing to drill a wildcat in the Waltham Creek area of Fresno County about 10 miles southwest of the Coalinga field. The well, Signal-Wood-Callahan-USL No. 77-24, will probe to depth of 4500 ft for evaluation of the Temblor sand. The location is in an area where Dauphin Development Company drilled a couple of dry holes on the Boone and Reagan leases 13 years ago, going to depths of 3754 and 4587 ft respectively.

★ Humble Oil & Refining Company is planning to drill an extension test on the south flank of the South Mountain field in Ventura County. The well will be drilled on a 586 acre lease on the Sence Ranch. South Mountain field is a faulted dome, discovered 40 years ago, and is the most westerly dome on the Oak Ridge fault.

★ Patrick A. Doheny, independent, has abandoned the test on the Crosby-Farrell lease in Fresno County at a depth of 9350 ft. Doheny's next venture will be Doheny-Crosby's Beer No. 1, which is expected to prospect to around 7400 ft in the Blackwells Corner area of Kern County.

★ Union Oil Company has made a new discovery one mile north of the Aliso Canyon field in Los Angeles County in sands between 7185 and 7759 ft. The well, Del Aliso 2-67X, is producing 215 bbl per day of clean 18.5 deg oil. The area is mountainous and highly faulted, however, and presents many exploration problems.

★ Union Oil Company is preparing to drill an offset well to the Costa 1 discovery in San Mateo County. This significant discovery, reported last month, was drilled jointly by Union and Richfield Oil Corporation, and is reported to be producing at a daily rate of 90 bbl of 42.5 deg crude from Eocene sands at about 2200 ft.

NEW YORK

★ Felmont Oil Corporation, a subsidiary of American Maracaibo Company, has a new discovery of natural gas in the southwestern part of the state. Located in Cattaraugus County, a wildcat well, the Lena Lockwood No. 1, has just been initially tested at the rate of approximately 8,000,000 cu ft of gas per day in the Oriskany sand found at a depth of 3754 ft.

KANSAS

★ William H. Pitts has underway a significant wildcat near the center of Oklahoma-Kansas border activity. The well, the No. 1 Joe Warren Ranch, is southeast of Silverdale in Cowley County and will go to about 3750 ft. The test is one-half mile north of the state line and on a northwestward trend from the Burbank play of northwestern Osage County, Oklahoma.

NEVADA

Richfield Oil Corporation is grading roads and location for Rabbit Creek No. 1 in the Lamoille area of Elko County, preparatory to drilling its first wildcat in the state. The drill site is some 11 miles southeast of Elko, and about 100 miles north of Railroad Valley in Nye County, where Shell Oil Company brought in the state's first production about a year and a half ago.

LOUISIANA

★ Drilling & Exploration Company Inc., has finaled a field discovery in the South Kaplan area of Vermilion Parish at its No. 1 R. D. Trahan. The well rated a final open flow potential of 70,000,000 cu ft of gas per day, plus 15.04 bbl of condensate per million feet. This gave a gas-liquid ratio of 66,509 ft of gas to one barrel of condensate.

Completion was made from Miocene sand at 11,152 to 11,167 ft. The hole was drilled to 11,188 ft and cased to 11,146 ft. Associated with Drilexco in the discovery are Harry Hurt, Houston independent, and Crown Central Petroleum Company. This operation first gave production indications last October, but on initial testing attempts the well blew out and caught fire; it burned for five days before being extinguished.

★ Completion of a wildcat in the Gulf of Mexico in the deepest water yet encountered in offshore operations has been reported by the CATC Group. On dual completion test on a 10/64-in. choke, the well, the State 953 Unit Well No. A-1, Grand Isle Area, Block 47, Jefferson Parish, flowed at the rate of 410 bbl of 37-deg oil daily at perforations from 13,614 to 13,620 ft and 348 bbl of 33 deg gravity oil daily at 9868 to 9874 feet. The well was drilled in 97 feet of water, approximately 20 miles off Louisiana. Nearest production is 15 miles.

★ Shell Oil Company has indicated completion of its wildcat well, the Myrtle W. Anderson No. 1, in the Boeuf River area of Franklin Parish, about 36 miles southeast of Monroe. On a 2-hour state potential test the well flowed through a 7.5/64-in. choke at a daily rate of 130.26 bbl of oil of 40 deg and 61,000 cu ft of gas from the basal Tuscaloosa formation. The well was drilled to a total depth of 7741 ft and plugged back to 7504 ft and will be produced from an interval of 7492 to 7498 ft. Flowing tubing pressure was 1000 psi.

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Exploration

TEXAS

★ Following two successful drill stem tests from the Devonian at depths from 13,014 to 13,068 ft, preparations are being made to set casing on the Husky Oil Company-Sinclair No. 1 Jines. This indicated new field discovery is located in north central Gaines County. It is two miles southwest of the recently discovered Devonian-Seagraves field of Anderson-Prichard, Husky Oil Company, and U. S. Smelting.

★ Drilling & Exploration Company, Inc., has established what appears to be a significant Devonian lime oil producing area in the Permian Basin in Dawson County. Completion is being made 8 miles northwest of Lamesa, at the No. 1 H. E. Wells, where on a preliminary seven-hour gauge the well produced at the rate of 39 barrels per hour through a 12/64-in. tubing choke. Flowing tubing pressure was 100 psi, and gas-oil ratio was low at 20 to 1. The gage followed a mud acid wash. The well is producing from section at 12,083 to 12,098 ft, where an earlier drill stem test indicated production possibilities. This well topped the Devonian formation at 12,030 ft and has approximately 50 ft of porous lime section.

Nearest established production to this discovery is about three miles northwest in the Mungerville, Pennsylvanian field.

★ Humble Oil & Refining and Pan American Producing has a discovery in Runnels County that opens up a new area for oil possibilities. The No. 1 Olitia Wilde Mueller was completed for a daily flowing potential of 455.85 bbl of 46.6 deg crude. Production was through a ¼-in. choke from an open hole between 3718-3730 ft. Gas-oil ratio was 135 to 1. This is the first well completed south of the Colorado River in that county. Production is from the Capps zone. Humble is now drilling its No. 1 Victor R. Wilde one-half mile east of the discovery under a 5500-ft permit. The discovery is about a mile east of Rowena townsite in an area of no nearby production.

★ Recent Paluxy sand discovery in Red River County, southwest of Bagwell in the northeastern part of the state, has touched off a fast shallow drilling play. The area was opened by I & L Development Company, whose No. 1 E. E. Morris is producing about 60 bbl per day through 6/64-in. choke from 2021-54 ft. Several operators have moved rigs into the area. Tentative name for the new field is the Mewhorn.

★ First major sour gas well was recently completed in Rains County in East Texas. Shell and Caraway have finaled the No. 1 Puckett, a 12,000 ft test, with one of the state's highest concentrations of hydrogen sulfide. The well, which has 42.5 per cent H_2S content, although originally completed late in September, has just recently finished satisfactory tests, due to poisonous nature and corrosiveness of the gas. Market and plant facilities for the well are yet to be estabished in the area.

NORTH DAKOTA

★ Amerada Petroleum Corporation has successfully completed its No. 1 Grimstead, 4 miles southwest of the Keene pool and 3½ miles north of the new Blue Buttes pool. On completion tests the well flowed 253 bbl of oil and 65 bbl of water a day on a 19-hour test from the Madison. Field name for the new McKenzie County well has not been chosen.

WASHINGTON

★ An exploratory well has been scheduled on the Olympic Peninsula, two miles north of the community of Sequim, by Standard of California. The company has tried in seven unsuccessful attempts in Washington to find oil since 1920. Last year Standard drilled two dry wildcats in the Pacific Northwest — one near Astoria, Oregon, and the other in the vicinity of Prineville, Oregon.

OKLAHOMA

★ Calvert Drilling Company, Oklahoma City, has opened a new area of gas-condensate production in Grant County in the north central part of the state. The company's No. 1 Dallem, 3 miles southwest of the South Prairie Home pool, was completed flowing 13,500,000 cu ft of gas and 90 bbl of condensate per day on an open flow test from formations in the Basal Pennsylvania sand at 4762-90 ft.

★ In Grady County, British-American Producing Company is in final stages of its No. 2 Harrison, which may prove gas production at a new record depth for the state. While coring at 15,000 ft, the well flowed gas from open hole at a rate of 9,000,000 cu ft.

KENTUCKY

☆ Shell Oil Company's No. 1 M. D. Davis, in Crittenden County, is hitting for a new depth in the state, with an objective of 9300 ft or basement. Well was last reported drilling below 6650 ft in the Knox dolomite.

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What's doing in DRILLING

★ **World's trouble spot,** for the moment, seems to be Israel. Oil, which never seems to enjoy pleasant surroundings, is making its debut in this disquieted area. All this, of course, lends importance to the small nation, befuddles the international diplomats, and angers its enemies. Meanwhile, in this country, all sorts of oil drilling, service and development companies are being organized and American oil personnel are being recruited for Israeli oil service.

★ **Israel's third test well,** being drilled by Israel Continental Oil, Ltd., is nearing its depth objective and will yield considerable light on the country's oil future. This company has nearly 800,000 acres broken into nine sections in Israel.

★ **American petroleum engineers** recently arrived in Israel to test the first discovery well for Lapidoth Israel Petroleum Company. This group will remain in the country for a short time, acting as consultants for future developments.

★ **Four drilling rigs,** costing more than $2,500,000, are being readied in Texas for delivery to Israel in the next three months. Two of the rigs are for Water Works, Ltd., and two are for the Matzada Company, a drilling subsidiary of Lapidoth and Israel Oil Prospectors, Ltd. Both are Tel Aviv companies.

★ **Over into Jordan,** an American oil producer has been granted government approval to do preliminary exploration work for the next eight months. At the end of this time, Edwin W. Pauley, a Los Angeles, California, independent, has permission to select up to one-third of the kingdom for drilling and development. The agreement stipulates that all profits will be shared evenly with the government after exploration expenditures have been regained.

★ **Cost of offshore drilling** is reflected on the price tag placed on Penrod Drilling Company's new self-stabilizing, submersible drilling barge. Penrod has awarded a $2,500,000 contract for its new barge to be used by The California Company for Gulf offshore drilling. Promised for August delivery, the barge will be 190 ft long, 150 ft wide and 90 ft deep. It will have living quarters for a crew of 50.

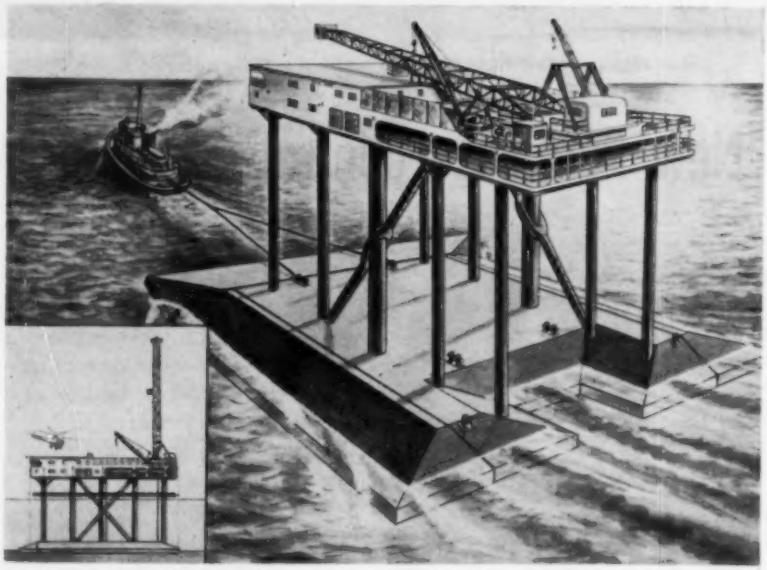
★ **Northwest of Edmonton, Alberta,** some 230 miles, Southern Production Company has begun a deep wildcat in the Valley View area that will be drilled as a 9600 ft pre-Cambrian test. Primary objective is a reef buildup in the D3 member of the Devonian formation. Southern Production, under an agreement with Canadian Atlantic Oil Company, Ltd., and others, is spending about $2,500,000 yearly on exploration and development in Alberta and British Columbia through June, 1958.

★ **Overall drilling picture** in the U. S. and Canada was never better than in December, although not without disappointments in certain areas. Only the Rocky Mountain area showed a blanket loss. Certain areas in California counted fewer active rigs, but most of these found work in other parts of the state. Michigan drillers say they drilled fewer wells in 1955 — 390 as against 433 in 1954.

★ **Permian Basin rig activity** is booming. Near the first of December, Reed Roller Bit people counted 610 rotary rigs running in West Texas and New Mexico, the most since the Spraberry boom of 1952. Andrews County, Texas, accounted for 100 of the active rigs, with Lea County, New Mexico, placing second with 75 units turning to the right.

★ **"Don't do anything rash!"** say Gulf Coast drilling contractors who were being begged to take contracts in December. Several new rigs would have been welcomed. Many claim the same operators won't touch them with a 10-ft pole in January, when business is back to normal. Lack of new rig purchases now, concurrent with periods of high rig activity in the past, has concerned some economists and manufacturers. Drilling association leaders suggest this may make for a healthier drilling industry in 1956.

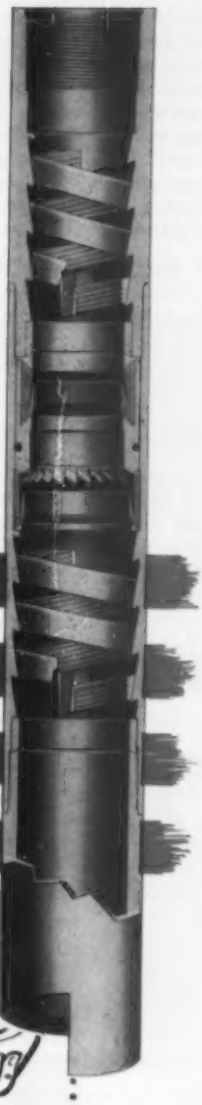
★ **Gas and air drilling** will be tried soon in Wise County, North Central Texas by Trio Drilling Company of Dallas. First well will be staked in the Cottondale area this month. Natural gas will probably be used for drilling about 400 ft of section between the Caddo and the Bend conglomerate. Gas well drilling in this area has stimulated activity beyond normal proportions. Trio Drilling has four rigs in the county and has drilled over 100 wells there since 1952.



CORAL DRILLING COMPANY, Fort Worth, Texas, has awarded contract on its new self-stabilizing, submersible drilling unit for use in its Gulf Coast offshore drilling activities. The 180 ft long craft, christened "Mr. Arthur," is designed for drilling in waters up to 67 ft deep. The vessel will be stabilized by four recessed pontoons operated hydraulically when the hull is being lowered or raised.

"data for the doghouse"

on BOWEN RELEASING AND CIRCULATING OVERSHOTS



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HERE'S A TOOL that gives you every advantage for quick recovery of fish to be externally engaged. Without adjustment it catches drill pipe—coupling *or* tool joint, whichever is up! And not only grips the fish in a patented non-crushing "grapple grip" that tightens as pull increases, but this Bowen Releasing and Circulating Overshot automatically mills and conditions jagged ends of the fish to permit full pack-off for high pressure circulation through the fish. A Bowen Releasing and Circulating Overshot is your best insurance against excessive lost time in the event of a twist-off—have one handy on your next well!

HERE'S HOW IT WORKS

TO ENGAGE THE FISH you need only connect the Bowen Overshot to the fishing string and run-in to the top of the fish. At this point, rotate right and let down until the fish enters the Overshot. For jagged ends of pipe, rotate slowly to the right as you gradually lower the fishing string. This allows the cutters to mill the jagged ends of the fish for full positive engagement and better seal when circulating. Once the Overshot is settled securely over the fish, neutralize the torque and pull up on the fishing string.
TO RELEASE FROM THE FISH drop the weight of the fishing string heavily against the Overshot. Then at the same time lift and rotate the fishing string to the right. This expands the spiralling grapple and permits easy pull-away from the fish.
TO CIRCULATE AND ROTATE when the fish does not come free on a straight pull, start circulation and while maintaining an upward pull, rotate *violently* as much as the fishing string will stand. The Bowen Releasing and Circulating Overshot is ruggedly built to withstand the toughest fishing jobs!

AND HERE'S THE REASON WHY

When a Bowen Releasing and Circulating Overshot is rotated to the right and lowered over the fish, drag of the fish against the bore of the grapple causes it to unwind and expand sufficiently to allow the fish to enter. As upward pull is exerted, the spiralling grapple is contracted by the tapers in the bowl to wedge and set the deep cut wickers about the entire circumference of the fish. The pipe grapple or the tool joint grapple grips firmly and evenly over a large area of the fish in much the same manner that the "Chinese Handcuff," illustrated at right, tightens when pull is exerted. As pull is increased, the grapple tightens about the fish and the greater the pull, the tighter the grip *without distortion* to the fish!

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Drilling

★ **Undersea drilling,** a new departure in offshore drilling technology, is being studied by a group of West Coast engineers. A method of drilling oil wells on the sea floor with rigs completely enclosed in a water-tight cone and manned by under-water crews is being considered. The plan was proposed by Charles K. Martin, Jr., of Los Angeles, California. The originator suggests that a submarine drilling rig would be operated in conjunction with a surface drilling tender to bring down supplies and men for drilling, which could be done at depths of 200 to 300 ft.

★ **West Coast core drilling** is being carried on in a new way by Richfield Oil Corporation. The work is being done by boat "held in position by four anchors. The drill line is guided on four cables fastened on a block of concrete which contains a hole in the center. The casing, when cemented in position on the floor of the ocean, has a funnel-shaped top which will guide the bit into position when coming back into the hole," says a newspaper account of the project. The activity is being carried on at Richfield's 1175-acre state lease about one mile offshore from Ventura.

★ **Mississippi River drilling** will be done via a new bird-in-the-nest technique by Magnolia Petroleum Company engineers. The idea involves use of a conventional shallow-water drilling barge that will be floated into place over a platform and sunk by taking on ballast. Weight of the sunken barge will wedge the unit tightly between pilings. If drilling finds commercial production, the barge then will move off and the underwater structure will be extended to 20 ft above the water level to hold production equipment. If no oil turns up the platform will be removed.

★ **First 1956 drilling program** of Signal Oil and Gas Company has been slated in the Redondo Beach area of California. In conjunction with this activity the company will enter into offshore drilling in the area with Reserve Oil and Gas and the Arnell Oil Company. The group received permission to do the tideland area recently. Signal spent from $12,000,000 to $14,000,000 for exploration and development drilling in 1955, a company official says.

★ **Hickory Holler area** of Rogers and Washington counties, Oklahoma, will get a bid as one of the most active shallow sectors for that state in 1956, according to reports. Montgomery Ranch drilling by the Texo Oil Company started the recent flurry of shallow drilling in connection with a waterflood project. Several rigs are staying active, with some companies planning to spend as much as $300,000 to develop the 1500 ft pool. Logs reveal five pay sections in going to this depth. These are the Dewey, the Wayside, Peru, Squirrel (Skinner), and Bartlesville sands.

★ **Leasing in Oregon** set new records in 1955, with a record 2,000,000 acres now under lease, according to Hollis Dole, director of the state department of geology and mineral industries. All this activity points to increased drilling and exploration activity in the state in 1956. Oregon land management office says it is several months behind in issuing leases filed since last spring.

★ **Determine costs carefully** and make sure business is conducted as efficiently as possible, is the advice given the drilling industry by Brad Mills, executive vice president of AAODC. These things must be done if the industry is to remain solvent and progressive. Analyzing the outlook, Mills said that future growth for the demand for oil never seemed so promising, and, since reserves do not look so high, a great deal of drilling must be done.

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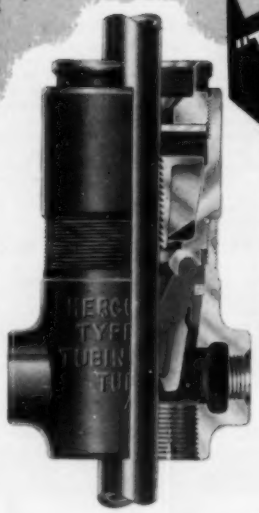
"Type J-5-S Stripper" TUBING HEAD for flowing wells



The dual-purpose "Type J-5-S" Stripper Tubing Head is basically a "Type J-5" Tubing Head with a bowl (top section) screwed into the packing nut thread. The hinged slips, packing and packing nut are installed in the bowl (top section) with the tubing stripper in the body (lower section), thus permitting tubing to be run-in, or removed under pressure. Test pressure is same as the "Type J-5" Tubing Head.

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★ **Reopening of some 500 heavy crude wells** is being completed by Tide Water Associated Oil Company in the Kern River field of Kern County, California. The wells were shut in about two years ago because of mounting heavy fuel oil inventories. The company is preparing a drilling program to further develop the field, reflecting the much improved fuel picture in that state.

★ **California drilling slump,** as reflected in last month's survey of the San Joaquin Valley, has idled a number of contract rotary rigs. Of the 79 rigs which normally operate out of offices in the southern sector of the valley, at last report only 49 were working, 16 of which were on jobs in other parts of the state. The lull is mainly attributed to the scarcity of new discoveries and the usual year end slack spell, particular to that section.

★ **Drilling lull in Michigan** has been blamed on the hunting season, the state department of conservation at Lansing has reported. Permits for the drilling of five new wildcats in as many counties, Arenac, Bay, Clare, Isabella and Montcalm, have been issued.

★ **Arizona,** having taken its place officially as an oil producing state, has a few rigs running. First commercial oil production in that state was brought in last month by Humble Oil & Refining at its No. 1 Navajo Tribal. Pending availability of storage facilities, the northern Apache County wildcat has been shutin. The well had a high gas-oil ratio, 87,344 to 1, producing 4,141,000 cu ft of gas on the completion test. Nearest oil production is a Shell Oil Company well 10 miles to the northeast, in Utah.

★ **Oil on Shamrock Hilton Hotel property** has been found in a well in Houston, Texas, drilled by Magnolia Petroleum Company, operator of the project, and Stanolind Oil & Gas. The 447-acre tract, originally belonging to Glenn McCarthy, whose touch was said to "turn anything to oil," became the property of the Hilton Hotels Corporation when the Shamrock was sold in 1954. The well was completed flowing 185 bbl daily of 34.7 deg crude through a 12/64-in. choke. It was completed at a depth of 7216-28 ft in the Vicksburg formation. Other wells will be drilled on the property, with the Shamrock Hilton getting full one-eighth royalty.

★ **Mid-December blizzards** have all but stopped the 43 wells drilling in Saskatchewan. Last reports dated December 1, 13 new wells have been spudded, 11 have been completed and two were abandoned as dry.

Rotary Rigs Operating in Oil Fields of United States and Canada*

	Nov. 14	Nov. 21	Nov. 28	Dec. 5	Dec. 12
Pacific Coast	145	145	147	145	152
Oklahoma	367	361	345	361	375
Kansas	193	194	198	199	199
Rocky Mountains	265	271	279	279	283
Canada	199	216	217	198	190
Ark-La-Tex	171	172	173	182	195
West Texas & New Mexico	608	631	601	635	653
Gulf Coast	602	613	598	602	648
Illinois	134	149	136	140	143
North Texas	364	362	352	372	380
	3048	3114	3046	3113	3218

*As reported to the American Association of Oilwell Drilling Contractors by Hughes Tool Company.

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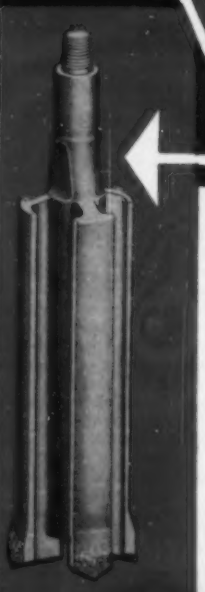

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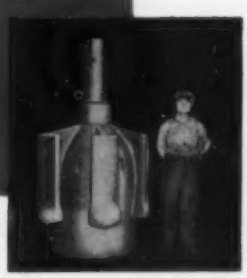

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RUNNING TOUR with MEN in the INDUSTRY

R. G. Kurtz

R. R. Simonson

R. G. Kutrz, formerly Los Angeles, California, division geologist of the Ohio Oil Company, has been given a special geologic assignment, and **R. R. Simonson,** geologist at Los Angeles, has been advanced to division geologist succeeding Kurtz. A veteran of 28 years' geologic experience with Ohio Oil, Kurtz joined the company at Casper, Wyoming. Simonson has been a member of Ohio Oil's geologic staff at Los Angeles since 1942. He earned his master's degree in geology at the University of California at Los Angeles.

Dr. Hollis D. Hedberg has been named coordinator and appointed to the production coordination staff of Gulf Oil Corporation. He will maintain close relationship with the company's exploration activities in both the Eastern and Western Hemispheres, and the scope and status of Gulf's exploration efforts on a world-wide basis. **Albert Gregersen** has been appointed staff representative for the Eastern Hemisphere production department. In his new capacity, Gregersen will serve as the Pittsburgh, Pennsylvania, general office representative for the vice president of the Eastern Hemisphere production department, C. W. Hamilton, who is stationed in London, England. Gregersen is a veteran of long experience, not only with Gulf, but as a practicing geologist, with particular experience in the Eastern Hemisphere.

Wilford Lee Stapp has joined with William J. Seidl as an independent geologist in New Orleans, Louisiana. Stapp was formerly district geologist for Sunray Mid-Continent Oil Company in Corpus Christi, Texas. He left the company after more than 10 years service. Seidl, who has been doing consulting work for the past two years, was formerly with Kerr-McGee.

Humble Oil & Refining Company has nounced the following changes in its production department supervisory personnel: **James A. Capeheart,** Grand Isle district, Louisiana division, was promoted from part-time driller to rotary driller at Grand Isle. **R. G. Condra,** part-time driller in the McCamey district, West Texas division, was promoted to rotary driller at Grand Isle. **P. E. Condra,** rotary driller, Grand Isle district, Louisiana division, was promoted to toolpusher at Grand Isle. **L. B. Watson,** rotary driller, Grand Isle district, Louisiana division, was promoted to toolpusher at Grand Isle. **J. S. Daniel,** rotary driller, Bayou Sale district, Louisiana division, was promoted to toolpusher at Potash, Louisiana division. **J. L. Cole,** rotary driller, Grand Isle district, Louisiana division, was promoted to toolpusher at Grand Isle. **R. F. Ewing,** toolpusher, Grand Isle district, Louisiana division, transferred to the Hobbs district, West Texas division, as toolpusher. **J. H. Reece,** rotary driller, Grand Isle district, Louisiana division, moved to the Sugar Valley district, Gulf Coast division, as rotary driller. **Marion M. Martin,** assistant district chief clerk, transferred from the North Katy district, Gulf Coast division, to the Stratton district, Southwest Texas division, as assistant district chief clerk.

Jesse E. Heller, civil engineer, Tyler, Texas, division office, was transferred to the civil engineering division, Houston, Texas, as civil engineer.

Murray J. Wells of Casper, Wyoming, has been named manager of the enlarged Mid-Continent division of Cities Service Oil Company's land-geological division. He will transfer to the company's Bartlesville, Oklahoma, headquarters about January 1. The division has been expanded to include northwestern operations. **Wm. M. Schulz** of Bartlesville will be division geologist and **Mark F. Payton** of Bartlesville will be the division landman for the enlarged Mid-Continent division.

Chairmen of 12 national standing committees of the American Association of Oilwell Drilling Contractors have been appointed.

Chairmen are: Accounting Committee, **C. H. Todd,** R. W. Rine Drilling Company, Wichita, Kansas; Cable Tool Committee, **D. B. Ferguson,** Ferguson Drilling Company, Oklahoma City, Oklahoma. Chapter Activities Committee, **J. L. Stauss,** Falcon Seaboard Drilling Company, Tulsa, Oklahoma; Insurance Committee, **J. Mark Gardner,** Delta Gulf Drilling Company, Dallas, Texas; Membership and Dues Committee, **Lloyd R. Pickrell,** Pickrell Drilling Company, Wichita; Public Relations Committee, **Frank G. McClintock,** Zephyr Drilling Corporation, Tulsa; Publications Committee, **George F. McQueen,** McQueen & Stout, Fort Worth, Texas; Research and Education Committee, **H. W. Davidson,** Davidson Drilling Company, Midland, Texas; Rotary Drilling Committee, **William P. Clements Jr.,** Southeastern Drilling Corporation, Dallas; Safety Committee, **W. S. Fitzpatrick,** Fitzpatrick Drilling Company, Corpus Christi, Texas; Taxation Committee, **W. N. Blanton,** Blanton Drilling Company, Houston, Texas; Transportation Committee, **Frank E. Frawley,** Frank Frawley Drilling Company, Tulsa.

M. F. Westfall has been named production superintendent for Husky Oil Company. **Jim Boydston** has been promoted from foreman to acting district superintendent of the Cody, Wyoming, district, and **Herbert Earnest,** production foreman at Midland, Texas, has been named acting district superintendent of the Midland district. Westfall, who graduated from the University of Colorado with a degree in civil engineering, joined Husky in 1952 as engineering assistant to the production superintendent and since 1954, has been acting production superintendent.

R. D. White has been appointed chief geologist of the Plymouth Oil Company with headquarters in Sinton, Texas. White will fill the vacancy created by the resignation of **W. H. Conkling.** White was graduated with a BS in geology from the University of Chicago. He resigned his position as assistant chief geologist of The California Company at New Orleans, Louisiana, to accept the position with Plymouth.

Richard F. Cox, former chief engineer, has been appointed general production superintendent of Southwest Gas Producing Company, Inc. In his new capacity he will supervise and coordinate production and drilling operations from the company's main offices at Monroe, Louisiana.

G. Otis Danielson has been appointed by Kerr-McGee Oil Industries, Inc., as manager of drilling operations in the company's Gulf Coast region. Danielson was formerly manager of drilling operations in Kermac's Mid-Continent region. He joined the company as a roughneck in 1940, a few months after his graduation from the University of Oklahoma with majors in petroleum engineering and geology. Danielson's present duties will be split three ways. **George B. Parks,** general manager of production and drilling operations, will assume part of the duties and responsibilities of the office. **Norman Baxendale** will fill the position of general drilling superintendent of the Mid-Continent region, assuming the balance of duties previously assigned to the office of manager of the Mid-Continent region. Bidding and contracting section of the Mid-Continent region will be placed under the supervision of **J. W. Bawcom.**

NEW OFFICERS OF THE PETROLEUM ENGINEERS CLUB OF DALLAS, Texas were elected last month. They are shown, left to right: President, J. W. Black, Magnolia Petroleum Company; first vice president—program, Kenneth W. Anderson, U. S. Bureau of Mines; second vice president—arrangements, R. A. Minter, Lone Star Gas Company; third vice president—membership, H. C. Brand, Schlumberger Well Surveying Corporation; secretary-treasurer, G. E. Roark, James A. Lewis Engineering, Inc.

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New Services • • • New Tools • • • New Methods • • • Outstanding Results

McCullough Log Saves $40.00 Per Foot Coring Cost in Offset Well

This was well #2 of a drilling program, an offset to the first well in the area which was cored completely. Depth of operation was below 5,000 feet. 5½" O.D. 15 lb. casing had been cemented through the pay zone.

A McCullough Radiation Well Log was run obtaining Gamma Ray and Neutron curves and a simultaneous collar log. McCullough's Logging Engineer computed porosities from the Neutron Log, applied shale and thin bed corrections and located the 18 foot oil zone to be perforated between 5,050 and 5,068 feet. The porosity graphs and slope of the curves were determined from cores from the key well.

108 improved ½" Ogival Bullets were fired in the pay zone, six per foot, by 4¾" O.D. McCullough M-3 Bullet Perforators. Result: A good well, and it took only four hours to complete the logging and perforating.

Other offset wells in the field will be completed in the same way, saving $40.00 per foot in coring costs through the zones that would ordinarily be cored.

This is another fine example of the accuracy and reliability of the McCullough Radiation Well Logger, and its outstanding value as a correlative instrument.

McCullough Log Helps Turn Water Well Into Oil Well

McCullough Radiation Well Logger Accurately Locates 3½ Foot Oil Zone Missed by Previous Log.

While this was a wildcat well, the producing horizon had the same general characteristics as other wells in the basin; the usual gas cap, a very thin oil zone and a transitional zone. It was a typical tough completion problem calling for exact, detailed logging information and "pin point" accuracy in perforating.

First logged and perforated by another service company, the well flowed water. Depth of operation was below 5,500 feet and 5½" O.D. 14.5 lb. casing had been set through the producing horizon.

After squeezing to shut off the water flow, the operator called McCullough. A McCullough Radiation Well Log was run obtaining Gamma Ray and Neutron curves and recording a simultaneous collar log.

The McCullough Radiation Well Logger is the most accurate, reliable and efficient logging instrument available. It has greater stability, provides more detail and assures more accurate quantitative interpretation. You can be sure of exactly locating, defining and interpreting potentially productive formations—thick or thin.

It was found that the previous log had been ten feet deep on casing collars, formation tops and total depth measurements. In addition the log had been interpreted so that the oil zone was shown to be 30 feet into the transitional zone.

The McCullough Log accurately identified and exactly located the gas cap, a 3½ foot oil zone, then the transitional zone. The gas cap contact was perforated for a squeeze shut-off and the 3½ foot oil zone was perforated by ten McCullough Super Formation Glass Jets. The well was then fractured and is now a good, commercial, water free oil well. Total logging and perforating time was only three hours.

There are many actual jobs such as this where the accurate, reliable, easily interpreted information provided by the McCullough Radiation Well Logger has turned a total loss into a profitable operation.

For best results, always call for the McCullough Radiation Well Logger. The most dependable logging equipment available.

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LOS ANGELES
HOUSTON
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Running Tour

J. Ryan Walker, has been named supervisor for the National Geophysical Company and will make his headquarters in Shreveport, Louisiana. Prior to joining National Geophysical, Walker was chief geophysicist for Arkansas Fuel Oil Corporation at Shreveport. He is a veteran of 25 years in the geophysical industry.

J. R. Walker

Harold Hansen has been promoted by The British-American Oil Producing Company from field engineer at Sterling, Colorado, to district engineer for the company's southwestern district, with offices at Midland, Texas. **John Freeman,** staff engineer, has been transferred from Midland to Sterling, Colorado. Hansen started with British-American in 1953 and has spent the last two and a half years in the Denver-Julesburg Basin. He completed his degree in chemical engineering at the University of Oklahoma.

William W. Walmsley has been named assistant division manager of Sun Oil Company's Rocky Mountain division, Denver, Colorado. Walmsley first joined Sun in 1951 as district landman at Billings, Montana, and was made agent and attorney-in-fact early in 1955. He attended Colgate University and received his Bachelor Science degree from Rutgers.

Donald J. Munroe of Tallahassee, Florida, and **Lee C. Smith** of Midland, Texas, have been appointed assistant regional geologists in Sun's southwest production division. Monroe and Smith will remain in Tallahassee and Midland respectively. At the same time appointments were announced of **Rex Alcorn** as district geologist at Roswell, New Mexico, and of **Walter L. Erwin** as geologist in charge of the Tallahassee office. Alcorn, who already is at Roswell succeeds **Edward B. Wilson.** Wilson has retired from the company after 29 years of service. Munroe began his company employment with Venezuelan Sun, Ltd., in 1926. First employed by Sun as a paleontologist at Dallas, Texas, in 1933, Smith was area geologist at Midland prior to his new position. Alcorn began work with the company as a subsurface assistant in 1948. Erwin joined Sun as assistant field geologist in 1948 at Tallahassee. He was previously assigned to the Roswell and Abilene, Texas, offices.

J. M. Starr, an executive assistant of Falcon Seaboard Drilling Company, has been elected a vice president of the company. Starr will be in charge of rigs and drilling operations in the Mid-Continent and Rocky Mountain areas.

He joined Falcon Seaboard in 1938 as a roughneck and was named assistant to J. L. Stauss, executive vice president, in 1951.

Gus Athanas has been named district engineer in the Lubbock, Texas, district office of Stanolind Oil and Gas Company. He fills the vacancy created by the resignation of **E. H. Blackaller.** Athanas had held the title of senior petroleum eningeer in Lubbock prior to his promotion.

He joined Stanolind in 1946 and holds an MS in petroleum engineering from the University of Texas.

Ernest V. Potter has been named manager of the land department for Sunray Mid-Continent Oil Company. Potter previously was division landman. He joined Sunray in 1952 as district landman at San Antonio, Texas. Potter studied at Kansas University and at Cumberland University, where he received a Bachelor of Law degree. **Harold Gimlin,** district landman for Sunray Mid-Continent in Lake Charles, Louisiana, has been promoted to division landman with offices in Tulsa, Oklahoma. He succeeds Potter. Gimlin joined the company in 1951. **Robert F. Hall,** landman at Lake Charles, has been promoted to district landman there to succeed Gimlin. **Eugene Barr,** senior geologist for Sunray Mid-Continent in the Wichita, Kansas, district office, has been transferred to Denver, Colorado, as district geologist. Barr has been on the Wichita staff for eight years. He is a graduate of University of Kansas. **Don Rector,** geologist in the Tulsa office, has been transferred to Wichita as a geologist in the district office.

H. C. McCarver has been named assistant vice president and assistant general manager of Mid-Continent division of Seaboard Oil Company, Dallas, Texas. McCarver was manager of the geological and geophysical departments of the division prior to his new appointment.

K. E. Peterson has been transferred to the Calgary, Alberta, office of National Geophysical Company of Canada, Ltd., as a seismic supervisor. Peterson was formerly seismic supervisor in the Denver, Colorado, offices of National Geophysical Company, Inc., and has been associated with National for nine years.

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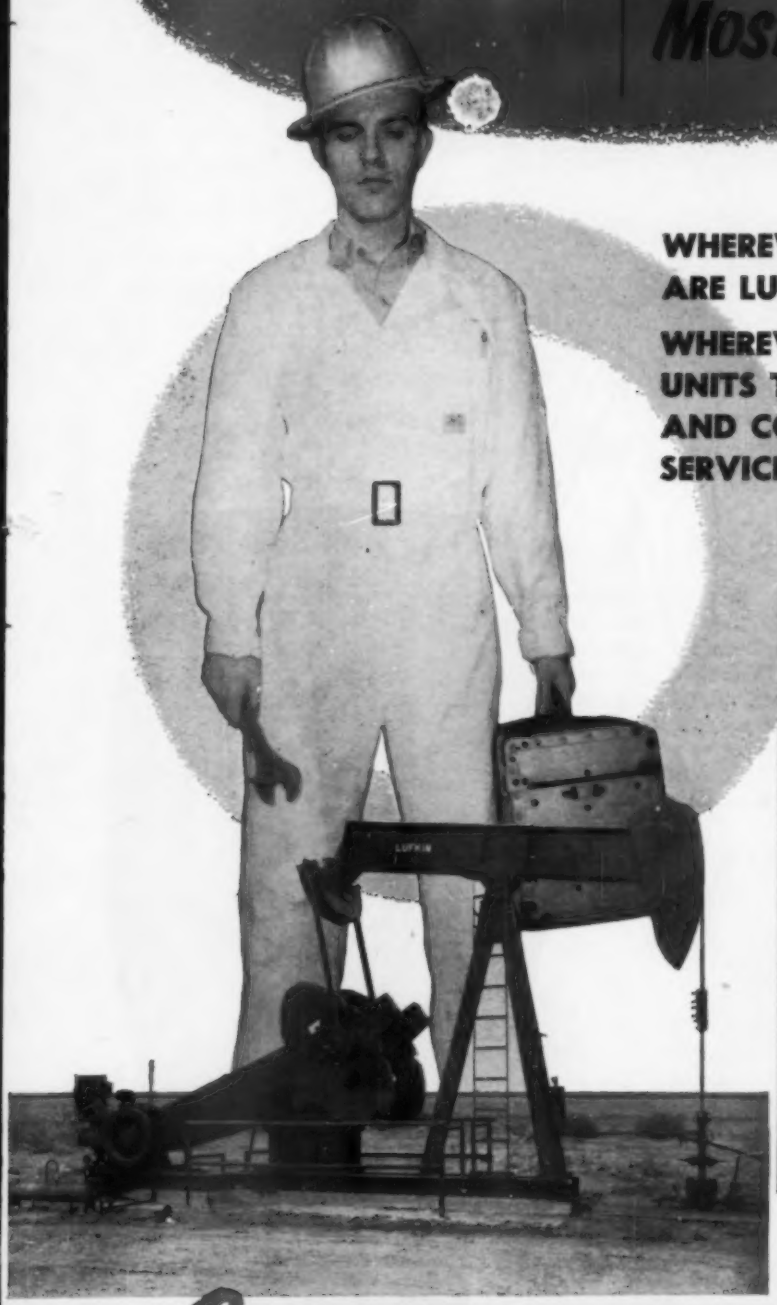

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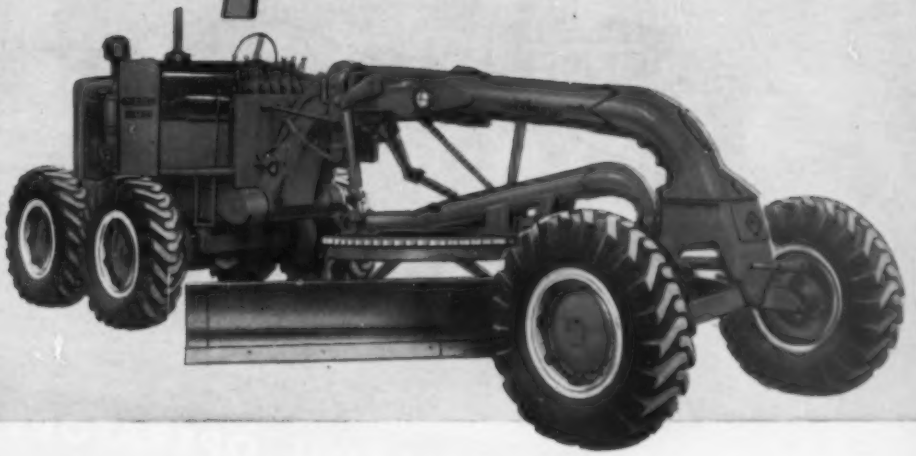

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We invite you to check the features shown here. Then for the full story on the *Forty Five* — including extra-big clearances, exclusive ROLL-AWAY* moldboard, single-member tubular frame, fully enclosed power steering, new, long-wearing ceramic clutch lining and unit construction for matchless service accessibility — see your nearby Allis-Chalmers dealer.

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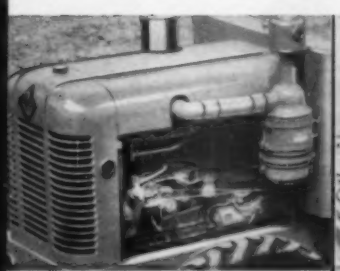
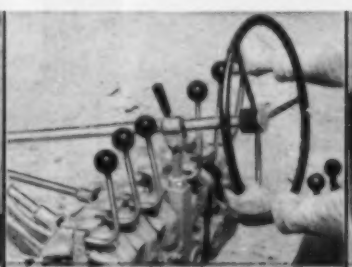
MAJOR ADVANTAGES THAT MEAN MORE PRODUCTION . . . LESS MAINTENANCE . . . EASIER AND BETTER OPERATION

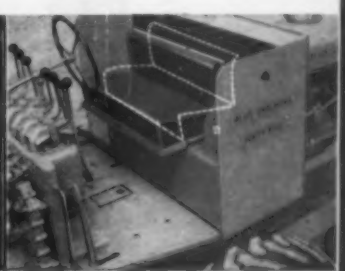


Powerful new Allis-Chalmers diesel featuring exclusive "follow-through" combustion for smooth performance, clean combustion, extra long life.



All-new toggle-type controls give a *Forty Five* operator precision control with positive "feel" — easy finger-tip action regardless of load.

New accelerator-decelerator pedal lets the operator change engine speed with his foot — without touching his hand-throttle setting.



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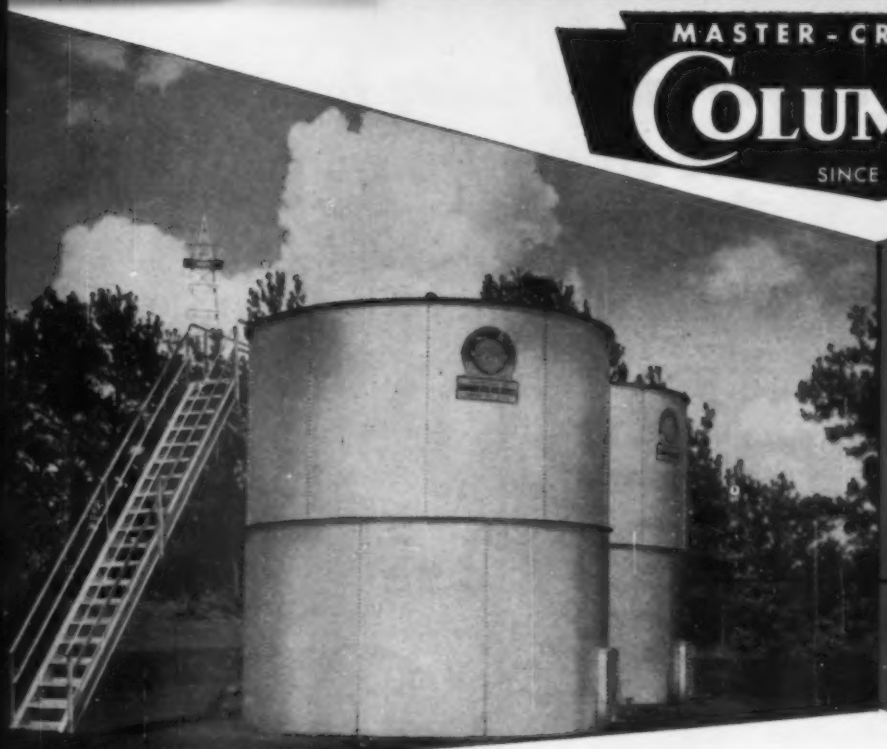

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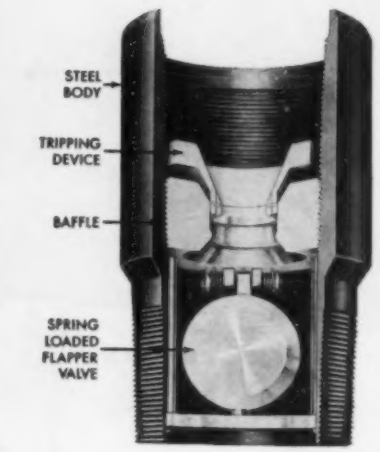

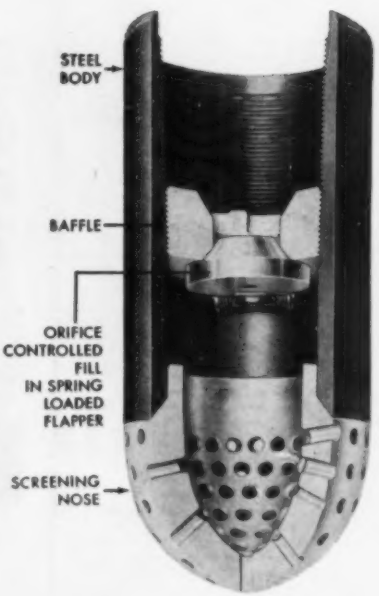

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The Type "O" Fill Shoe has a perforated aluminum alloy nose and baffle which is equipped with spring-loaded flapper valve with orifice choke. Orifice inserts are available in various choke diameters engineered for all pipe sizes.

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If casing is run to total depth with orifice fill, ball is not used. Seating of cement plug on fill collar releases and closes flapper valve which then acts as back pressure valve, providing positive flow-back control.

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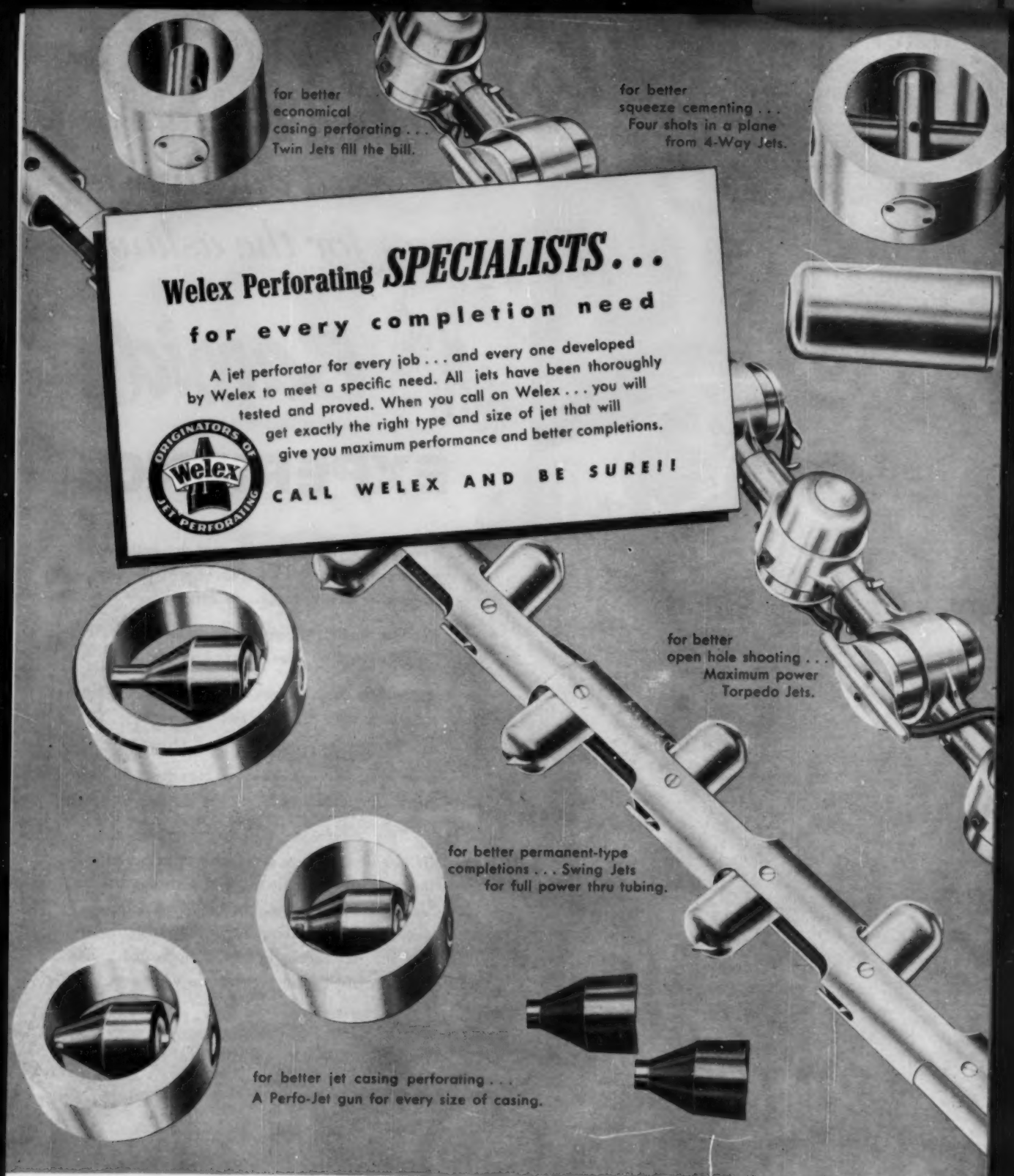
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A jet perforator for every job . . . and every one developed by Welex to meet a specific need. All jets have been thoroughly tested and proved. When you call on Welex . . . you will get exactly the right type and size of jet that will give you maximum performance and better completions.
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for better open hole shooting . . . Maximum power Torpedo Jets.
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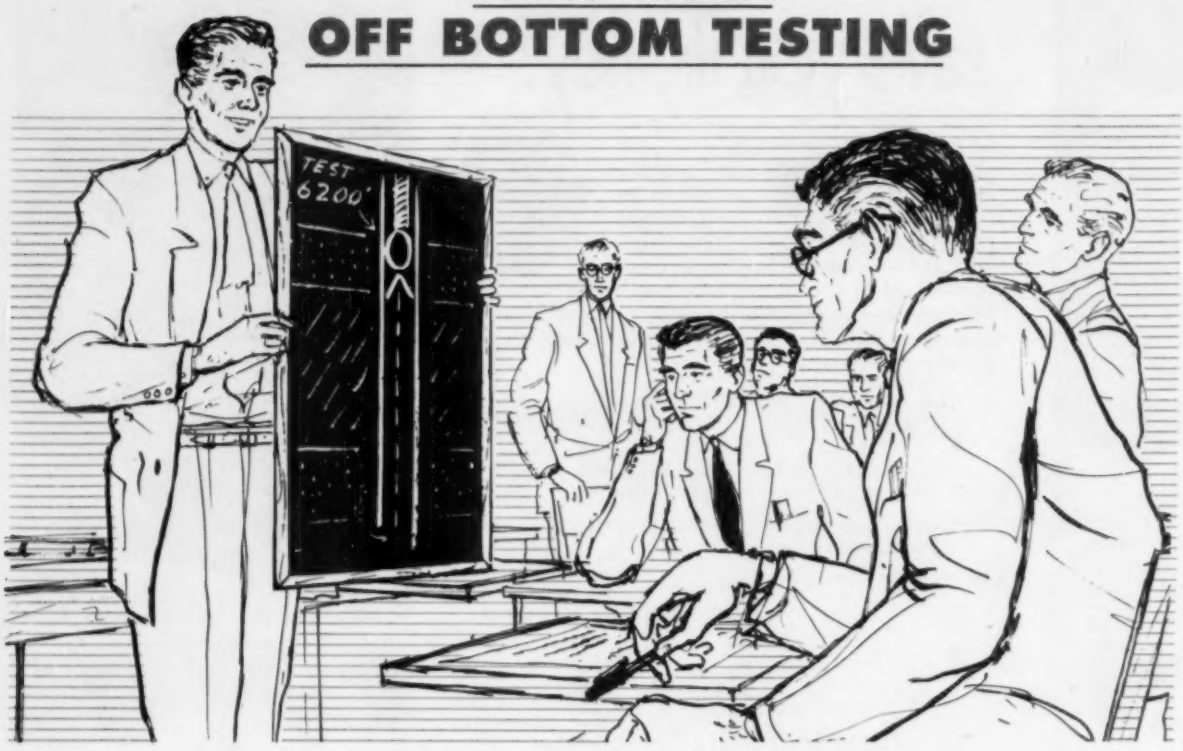

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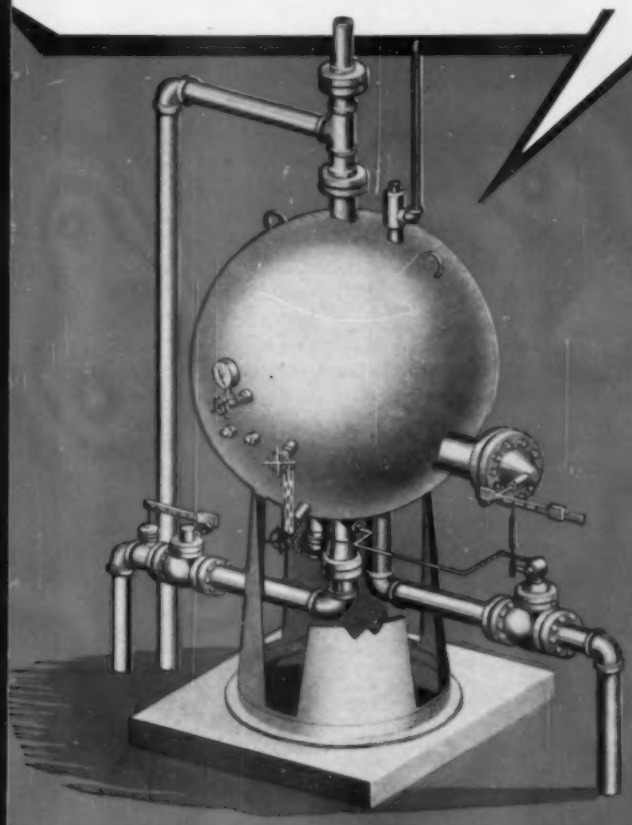

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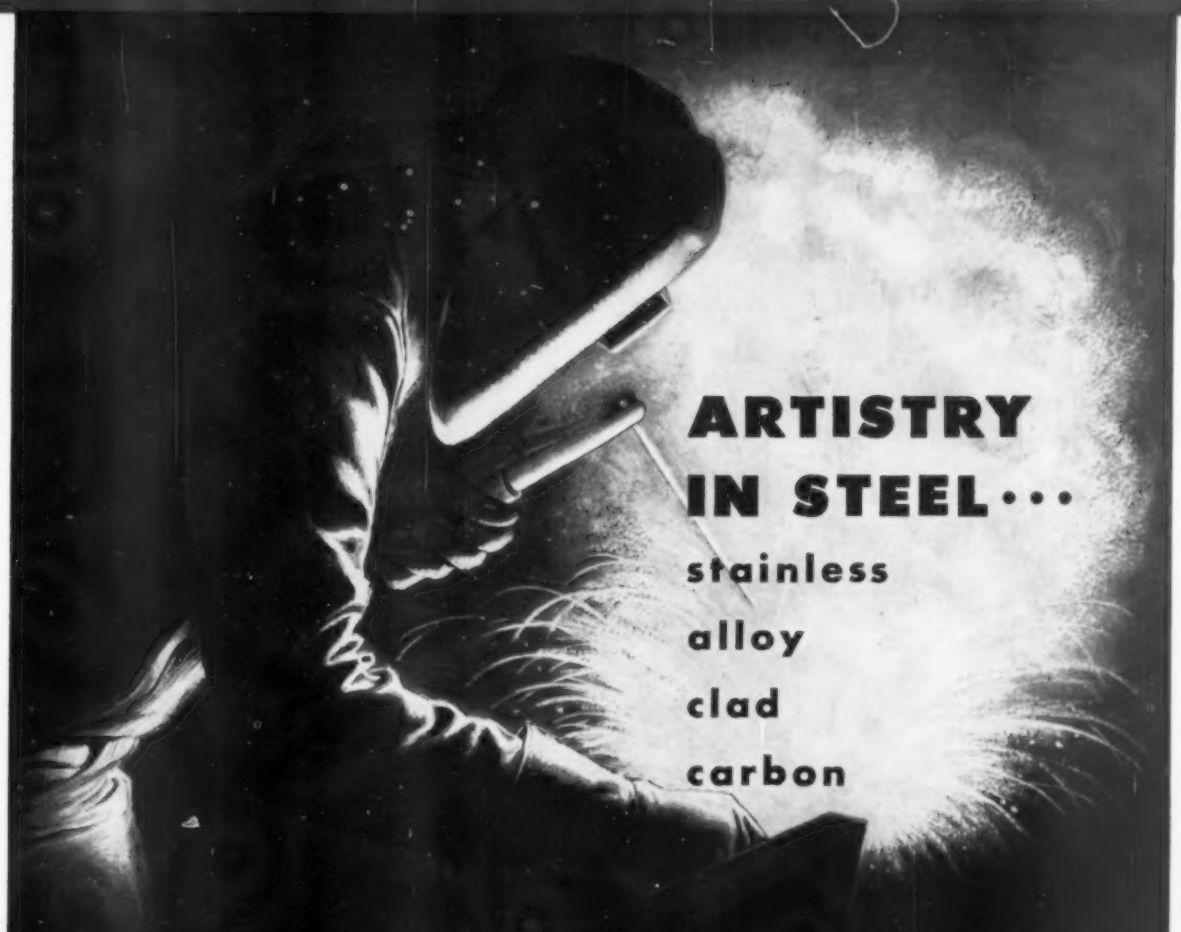

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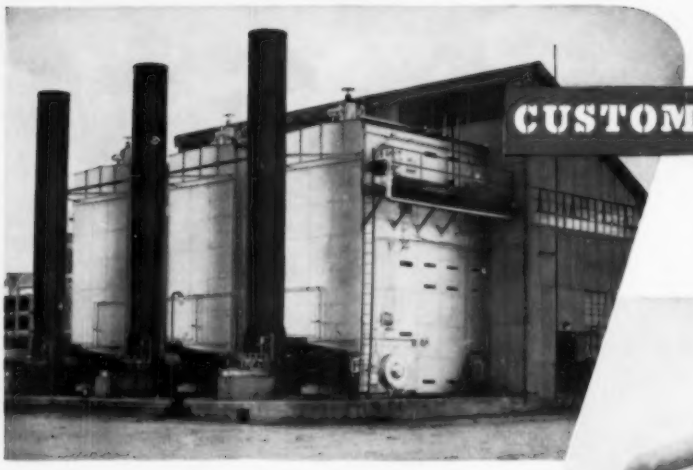

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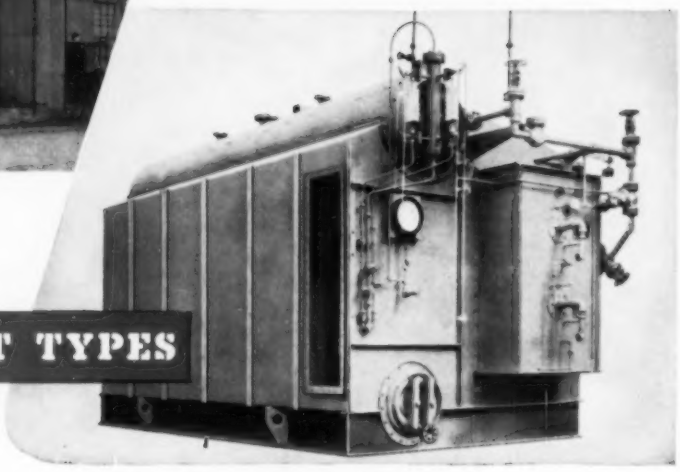

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NEWS and COMMENT

Scientists – Fuel Pumps – Atom Smashers – Automation

SETTLE CAT CRACKING SUIT. Houdry Process Corporation and Socony Mobil Oil Company, Inc., have decided to bury the hatchet on the only "serious" patent infringement suit in the annals of the young and most lusty cat cracking industry. Houdry sued Socony for infringement on the former's cracking patents. Long and meticulous study and counterstudy, charge and countercharge, has finally elicited the following items of agreement, as announced by officials of both companies, to be completed before year's end.

Companies will exchange full and complete immunities for moving-bed cat cracker operations, including the new Houdresid process, for themselves and licensees. Both will grant irrevocable rights to present and future licensees as royalty-free immunities for inventions in this field during a five-year period beginning January 1, 1956. Socony pays Houdry $3,000,000; will pay Houdry $12.50 per barrel capacity for any licenses issued during the coming five-year period, for paid-up royalties, ¾ cent per barrel out of running royalties, until $12.50 has been paid on these licenses.

* * *

GAMMA RADIATION—Can it refine crude oil at room temperatures, eliminating the necessity for the expensive and fuel-consuming heating units now employed universally for distillation and other processes in oil refineries? E. G. Murphree has indicated to newsmen that exposure of crude oil or its fractions to the radiations from a more-than-foot-long section of radioactive cobalt pipe has shown possibilities of revolutionary advances in refining techniques. All are inclined, however, to remember the "there's many a slip 'twixt the cup and the lip" in refining technology as in other fields of human endeavor.

* * *

MORE SYNTHETIC RUBBER by Canadian firms for Canadian consumers, say the government officials of Alberta. "If we do not make rubber from our vast natural resources, then 'Them Yankees'll be coming,' to make it for us," say our northern neighbors. The urge is that one or more of the Canadian rubber companies move in and fill the gap by using natural gas in Alberta for this purpose. The advantage to the province and to Canada is obvious. No moves have been announced as yet.

MERGERS OF CHEMICAL and of refining-petrochemical companies may be slowing down, according to the latest developments in these lines. Reichhold Chemical — whose boss, Henry Reichhold, owns the largest single block of Catalyn stock — about 10 per cent — has confirmed, as has Catalyn, that the earlier rumored merger plans for those two companies are "off." Next step may be a "dogfight" for control of the two companies to make possible a legal decision to merge.

* * *

FURTHER: Vick Chemical and Spencer Kellogg are not in the state of "all's beer and skittles" on the subject of the rumored (proposed?) merger of the two outfits; outsiders appear to have a potential appetite for fractions of the S-K pie, and the outcome at this writing is in the Lap of the Gods.

* * *

TWO OTHER COMPANIES, Hercules Powder and American Viscose have discontinued their plans for amalgamation as being impracticable as of the present; this combine would have had assets placing it among the largest in the chemical and petrochemical industries, totaling nearly half a billion. Whether any of these actions are final remains to be determined. The future holds many "wild cards" in its deck.

* * *

HALOGENATEDHYDROCARBONS may be made by Penn-Salt Manufacturing Company, in its multimillion dollar plant in Calvert, Kentucky, now being built. With a series of products called by the trade name Isotron, the members may include several substituted methanes and ethanes, such as trichloromonofluoromethane, trichlorofluoroethane and similar substituted hydrocarbons, important in many phases of the petrochemical industry.

* * *

BRITISH CAPITAL and chemical interests are looking longingly at American plant sites and markets. Most recent is the pilgrimage of the British Imperial Chemical Industries band of experts, studying the San Francisco Bay area in California for a possible site for a polyvinyl chloride plant. Not a new idea to either British or American chemical leaders, it shows, among other things, the wish of European manufacturers to dig into the American industry for profits and business.

OBSOLESCENCE is the inevitable destiny of not only equipment and processes, but of products, plants, locations and situations. Much asphalt has been made from the black crudes of the Rocky Mountain region. Most refineries in that area produce and market it, including the refinery of Ohio Oil Company at Lovell, Wyoming. Now that plant is to be shut down, either dismantled or sold in situ, says Ohio's president, Donnell. Down to half its 6500 B/D capacity for the past two years, the limited "local market" and the excessive cost of shipping products to more distant and larger markets are all conditions that have made the whole operation uneconomical.

* * *

SYNTHETIC RUBBER bids fair to take over more and more of the American and other markets as expansion of capacities are studied and authorized. Texas-U.S. Chemical is to expand its capacity at Port Neches, Texas, to 75,000,000 lb per year destined almost entirely for the American market, it is said. The British Dunlop people, in the traditional home-control center of natural rubber, is said to be considering building synthetic rubber capacity in Britain to augment its supply of the natural product. Final outcome of the latter proposal is not known — yet.

* * *

FIVE SAFETY AWARDS were given Lion Oil Company, a Division of Monsanto Chemical Company, recently in recognition of safety achievement, four at the El Dorado chemical plant and one to the general service department. Individual safe-working awards were also presented at Lion's three manufacturing installations to 141 employees and to seven general service personnel.

* * *

MODERN PROTOTYPES of the age-old moonshine still continue to be the most important developments in the modern chemical and petroleum industry, it was reported at the American Institute of Chemical Engineers Annual Convention in Detroit. All liquid fuels and lubricants from petroleum, many medicines, acids, and organic chemicals such as dyes are produced or purified for use by distillation. Without the still, the world would still be in chemical dark ages. Investigations are a continuation of a recent trend toward a more fundamental approach to distillation operations.

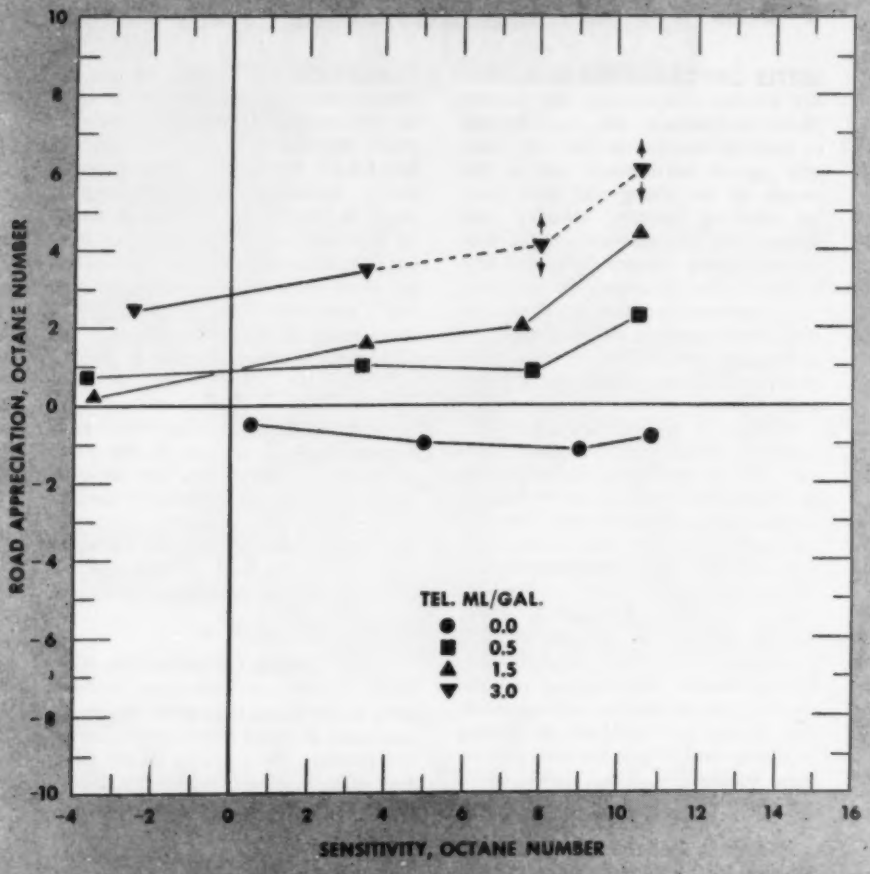

Fig. 1. Sensitivity versus appreciation. Note that the appreciation at any given sensitivity level increases with lead concentration.

Blending Hydrocarbons for Maximum Octane Potentials

By F. D. BUERSTETTA
Ethyl Corporation, Detroit, Mich.

The manufacture of high-octane gasolines to meet today's and tomorrow's automotive demands is putting increasing pressure on the refiner. To meet these requirements, the available hydrocarbon components in the refinery must be blended to best advantage to give maximum performance on the road.

Each octane number at the 100-octane level may cost as much as 15 to 20 cents per barrel. Thus there is a marked incentive for insuring that every laboratory octane number, obtained at this great expense, provides corresponding antiknock performance in cars on the road.

Hydrocarbon blends studied

As part of a continuing Ethyl Research program to establish the fundamentals of laboratory versus road antiknock quality, a study was recently conducted in which the behavior of blends of pure C_7 and C_8 hydrocarbons was examined.

Within this C_7-C_8 range, the four basic hydrocarbon types — olefins, paraffins, naphthenes and aromatics — were blended in varying proportions. Actually, a mixture of isooctane and *n*-heptane was used as the paraffin constituent to permit maintenance of a constant Research octane number while investigating the effects of tetraethyllead concentration and variations in hydrocarbon-type composition. Toluene, diisobutylene and methylcyclohexane were selected to represent the aromatics, olefins and naphthenes, respectively. Each of these hydrocar-

Send for your free copy of a technical paper entitled "Octane Possibilities with C_7-C_8 Hydrocarbons" by F. D. Buerstetta and T. W. Warren. Address your request to Box 12, Ethyl Corporation, 100 Park Avenue, New York, N.Y.

bons was blended in concentrations of 20, 40 and 60 per cent by volume with the proper paraffin mixture, giving nominal Research octane levels of 92, 96 and 100 at each of four tetraethyllead concentrations—0.0, 0.5, 1.5 and 3.0 ml. per gallon.

Each blend was evaluated in single-cylinder laboratory test engines and was then rated in the 9 to 1 compression-ratio engine of a 1955 passenger car equipped with an automatic transmission. Road ratings were made by both the Modified Uniontown and Modified Borderline techniques.

Road appreciation defined

Some of the test results are summarized in Table 1 in terms of road appreciation, which is the road antiknock rating of a fuel minus its Research octane number—or the bonus obtained in actual engine performance over the indicated laboratory knock rating.

The general analysis of data shown in Table 1 may permit a refiner to achieve better road performance than could be secured by using only Research octane number as a guide. It will be seen that aromatics should be maximized and olefins minimized as much as possible when making top-octane fuels. Since most of today's catalytic reforming processes eliminate naphthenes through dehydrogenation to aromatics, consideration of them is somewhat academic, but nonetheless interesting.

Further evaluation of the large quantity of test data obtained from this project indicates a most interesting correlation between appreciation and the concentration of tetraethyllead. Figure 1 shows a plot of sensitivity versus appreciation with points representing the same tetraethyllead concentrations connected. It can be seen from Figure 1 that the appreciation at any given sensitivity level increases with lead concentration.

Conclusions

The general conclusions which can be obtained from the study are as follows:

1. Best over-all antiknock performance can be obtained by blending a high proportion of aromatics with paraffins and adding the maximum amount of tetraethyllead.

2. Where low-speed knock resistance is critical, high aromatic content is necessary.

3. Where high-speed antiknock performance is critical, high aromatic content is less important, but maximum tetraethyllead concentration is still essential.

Table 1. Average change in road antiknock appreciation with addition of aromatics, olefins or naphthenes to paraffins in the C_7-C_8 range.

Research Octane No.	Added Component	Modified Uniontown	Modified Borderline	
			Low Speed	High Speed
92	Aromatics	+0.6	+1.1	+0.6
	Olefins	+0.3	+1.1	−2.0
	Naphthenes	+0.6	+2.0	+3.8
96	Aromatics	+0.9	+1.7	+0.6
	Olefins	+1.6	+1.1	−3.3
	Naphthenes	+2.4	+4.2	+2.7
100	Aromatics	+0.8	+1.5	−0.7
	Olefins	+0.5	+0.0	−5.7
	Naphthenes	+3.4	+3.7	+1.7

HOW Ethyl Research can help you

At today's high octane levels, the science of blending hydrocarbons has taken on more and more importance. As a service to the oil industry, Ethyl Research has launched a hydrocarbon blending program of its own to complement the intensive effort which the industry is devoting to this problem.

We are now testing many new blends in our laboratories and in high-compression engines on the road. Much of the data from these tests is being interpreted in terms of "road appreciation" to give refiners a better idea of the effectiveness of each blend. Write for a copy of "Octane Possibilities with C_7-C_8 Hydrocarbons"—another in the continuing series of reports from the Ethyl Corporation on fuel blending and other studies of vital interest to refiners today.

For further information, just call your Ethyl Representative. He'll be happy to arrange an appointment for you with one of our Technical Representatives.

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Research Laboratories:
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THIRTEEN-FOURTEEN MILLION BARREL per day crude requirements are expected by 1965 as compared to or nearly 8,000,000 bbl for 1956, said John G. Winger of Chase Manhattan Bank before the API in San Francisco. All recent estimates of demand and consumption have been low, it is well known. Estimates of our population of more than 193,000,00 by 1965 along with curves of projected consumption support these figures. Natural gas demand will run along at about its present 8½ per cent yearly increase, says N. B. Guyol, UN staff statistician. Distillates from petroleum will rise annually in demand some 7 per cent until 1960, 5 per cent after that to 1965. Interesting enough, residual fuel oil will remain stable at some half billion barrels per year, which means a lesser and lesser percentage of processed crude going into resids. By 1965 Guyol expects nuclear energy utilization to cause a slack-off in the consumption of other liquid and solid fuels. If present rates of liquid and gaseous fuels on solid (coal) continue, all coal will be forced out of use by 1963. Petroleum would be 'out' a few years later. This is not expected since all these fuels are able to compete with gas.

Question rises: Can we produce enough gas to do all these things?

★ ★ ★

BETTER AVIATION FUELS a must, says retired 3-star general Jimmy Doolittle — whose history belies his surname — in outlining what the aviation industry and the fuels industry are both facing. Something more efficient per pound of fuel than are pure hydrocarbons must be found. Rate of growth of demand is shown by comparison: "ancient" P-40 Army plane needed 1200 lb of fuel to fly 800 miles; F-85 flies twice as fast, uses 4 times as much fuel; B-52 burns 10 tons per hour, must carry 30,000 gal (three tank cars) for one flight. If the petroleum industry can come up with a special out-of-ordinary fuel with much more energy per pound and per barrel, and that is within permissible cost limits, it will affect profoundly our national security, solvency, defense, he says, in effect.

★ ★ ★

RADIOACTIVE SNOOPERS are being employed by Shell Oil & Shell Development—as by many other companies—in quantities less than five parts per million, and including active scandium, chromium and cerium, to run down and tag the reactions and goings-on inside a fluid cat cracker. Gamma-ray emitters—all easy to detect in small amounts, when combined with the sensitive radiation-measuring equipment developed recently—permit low-cost and exact tests. Test runs cost from 25 cents to $2-3. Catalyst regeneration, catalyst mixing and other phases of the work include deactivation rates for catalysts under varying conditions. Commercial models of these radiation counters are to be marketed by Tracerlab of Boston. (C & E N)

★ ★ ★

CATALYTIC REFORMING has permitted the improvement of processes and products never dreamed of by the progenitors of the reformer routine. Now come distillate fuel oils, good products but unstable after long waiting, due largely to unsaturated and sulfur-containing ingredients traceable to catalytic cracking. Many of the light-distillate fuel oils are composed largely of cat cracker recycle stock diverted to use "as is." Gulf Oil brings out a process, Gulfining, that with hydrogen and a suitable catalyst knocks out 80 to 90 per cent of the sulfur, lowers carbon residue, stops sludge formation, makes the fuel color-stable, boosts API gravity 1.0 to 2.0 deg, and will upgrade a deteriorated stock that has formed sludge to equal a fresh stock and requires no stabilizing agent.

★ ★ ★

PROTECTION FROM atomic bomb attack is one of the far-reaching and ultimately important considerations that must occupy the best minds of the oil and other industries, say our leading industry minds. Five bombs could destroy 60 per cent of our national capacity to build electronic instruments, equipment all-important to atomic warfare, says Dr. R. L. Janes of Armour Institute. Destruction of 10 metropolitan areas could eliminate 50 per cent of our petroleum production, more than half of our electrical machinery production capacity. All this at a Chicago meeting of scientists, government officials and businessmen, held to consider ways and means to minimize this catastrophe.

★ ★ ★

ATMOSPHERIC NITROGEN may be the arch-culprit in the formation of the obnoxious smog troubling the West Coast and other cities, says Lauren B. Hitchcock, head of the Air Pollution Foundation. Invisible organic compounds react in sunlight with nitrogen oxides to form smog — visible particles of the reaction products. Control of the nitrogen oxides is the primary problem, Hitchcock indicates. Control of automobile exhaust gases is one of the major tools for reducing smog, the report indicates.

SUPPLYING HEAT to run engines has been the job of combustion fuels since engines were first invented. Now come the aero-sharks who say that one of the big jobs for jet fuel is to serve as "heat reservoirs" or absorbers to take up the excessive heat to which faster-than-sound planes are subjected. The fuel must be able, and stable, to absorb this heat without decomposing, and then go on and be burned in the jet engine in the conventional manner. If the fuel is not stable at the temperatures it reaches when employed as a coolant, it forms insoluble materials that clog the fuel system, burners, jet and other parts of the engine.

Merely Another Headache for the refiner. Could it be that the engine designer should correct his own troubles, instead of blithely passing them on to the refiner?

★ ★ ★

PETROCHEMICALS and plants producing them seem to be falling into a typical and doubtless inevitable pattern. U. S. Industrial Chemicals has decided on Tuscola, Illinois, as site for its isosebacic acid plant — made from sodium, sulfuric acid, butadiene — readily available alongside from National Petrochemicals Corporation, there, which has oodles of hydrocarbons. Presumably will build a butadiene plant, to make same from surplus butanes from its processed light hydrocarbons. Process not being discussed, except that it apparently is based on French patent No. 1,093.096. Information seems to be (CW) that they dimerize butadiene, tack sodium onto each end of the 8-carbon chain, react with carbon dioxide and release the resulting acid with sulfuric acid, to make also sodium sulfate by-product. Carbon dioxide may be made in USI's gas reformer, where it produces hydrogen to up its ammonia production at the same site.

Talk about "Integrated!"

★ ★ ★

INDUSTRIAL CONSTRUCTION IN 1956 may exceed the rate shown in 1955 by as much as 15 to 20 per cent, says Walter Kidde Constructors. Modernization and expansion of facilities, boosting plant efficiency, added capital available because of mergers, production diversification and technological improvements are included in the causes of this expansion continuation. New developments of a great number of items are part and parcel of the causes for the extraordinary expansion rate now being shown by industry "all over." Construction costs are expected to rise in 1956, largely due to labor's increased costs.

"ANALYTICAL EQUIPMENT, METHODS"

Determines Content of TEL, additives with required accuracy; Saves large amounts in cost by controlling compositions

X-ray Answers Knotty Refining Questions

Vern W. Palen
North American Phillips Company

On an arm of San Francisco Bay, where the Sacramento and San Joaquin Rivers meet and move toward the sea, is the town of Martinez and the huge Shell Oil refinery which occupies 625 acres. Proper control of the processes that go on here day and night are the responsibility of the control laboratory and X-ray analysis plays an important role in this work.

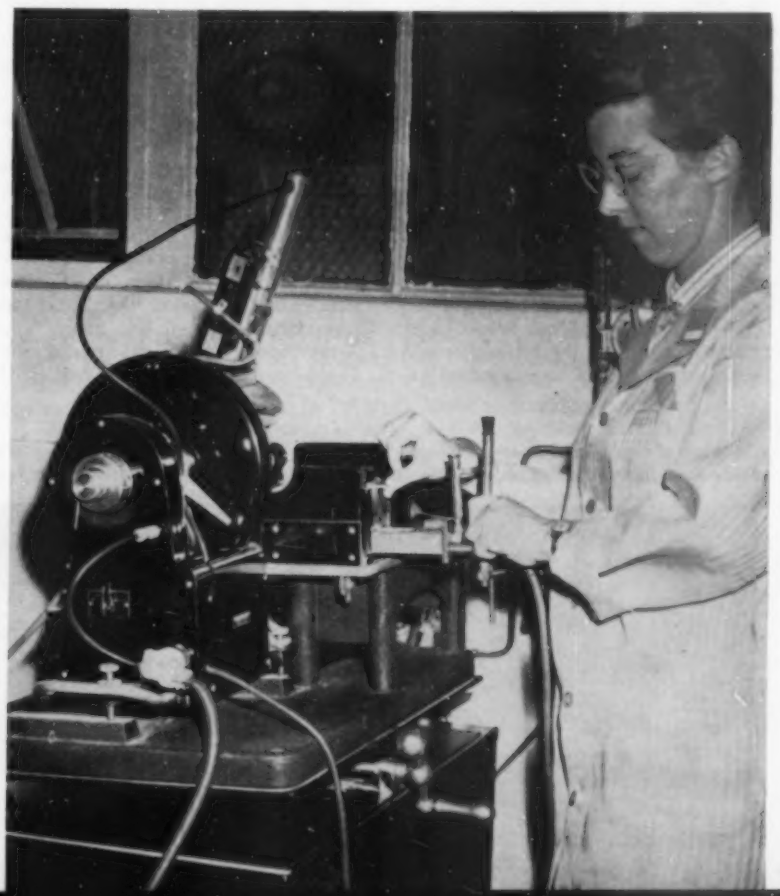
The X-Ray Spectrograph, which records the X-ray fluorescence of materials under examination, is employed at the Martinez refinery for production control. X-ray methods, because of their accuracy and rapidity, have now replaced many of the older wet chemical methods for the identification and quantitative determination of metals in petroleum products. These newer techniques are now routinely used to measure the tetraethyl lead (TEL) content of gasolines and to determine the additive content of lubricating oils and greases.

Government regulations limit the TEL content of gasolines and economic reasons make it necessary to carefully control the amount of this additive. For example, in a 40,000-bbl blend of gasoline there are 1,680,000 gal and if specifications call for 2.75 cu centimeters of TEL per gallon the TEL will cost about $10,000. This means it costs $360 to add 0.1 cu centimeters of TEL per gallon to the 40,000-bbl blend and it is important, therefore, that the analysis be accurate to within 0.1 cu centimeters of TEL per gallon. X-ray analysis is capable of giving this accuracy and the results can be obtained in 10 min whereas with wet chemistry the same determination would require 2 hours.

The control laboratory at Shell's Martinez refinery has developed a special specimen cell for gasoline samples that markedly increases the ease and rapidity with which TEL determinations can be made. This cell is a small, flat, rectangular aluminum container which is closed on top by a thin, transparent plastic (Mylar) film through which the X-rays pass. The metal walls of the container have cold water flowing through them to maintain the sample at a constant temperature. Two copper tubes lead into the sample cell so that it can remain in the X-ray Spectrograph while gasoline samples are changed. One of these tubes enters at the bottom of one end of the cell and is used to fill and drain the cell. The other tube enters at the top of the opposite end and serves as an overflow through which bubbles of air and vapor are displaced. In conjunction with this cell, Shell people use a special device which allows them to tip the spectrograph and sample cell to assure that all bubbles are displaced into the copper overflow tube and out of the cell. The removal of all bubbles is necessary as their presence interferes with the analysis. The use of this cell has simplified the running of TEL determinations and has markedly decreased the time required for the analysis.

In the Shell procedure for the determination of TEL a sample of the gaso-

EXCLUSIVE



X-ray diffractionist is shown inserting water-cooled specimen cell into X-ray Spectrograph.

Chart shows undesirable zinc in oil additive which gummed up machine.

line to be tested is diluted with iso-octane and is cooled to 60 F. The diluted and cooled sample is then transferred to the cell which is maintained at 60 F by the cooling water. The amount of fluorescence from the lead is then determined and this is compared to that from standard samples of TEL in iso-octane. This comparison gives the amount of TEL in the diluted sample and from this the TEL content of the gasoline sample is calculated.

In manufacturing approximately 1500 different petroleum products, Shell uses over 400 additives which serve very useful purposes. For example, when detergents are added to motor oils they reduce wear, promote engine cleanliness, and reduce sludge formation. Many of the additives used by Shell contain metals and X-ray methods can be used to assure that the additives have been added in correct amounts by determining the metal content of the products.

Many special problems are submitted to the Shell control laboratory in Martinez and X-ray methods are frequently used in seeking solutions to these problems. One such case involved the formation of a gum-like precipitate in a machine using a Shell oil. Specimens of the precipitate were examined by X-ray analysis and the undesirable material was found to be a zinc soap. Since the oil itself could not produce such a compound an examination of the additives in the oil was undertaken. One of these purchased items contained zinc as a contaminant and this was the cause of the trouble. Specification tests were then set up to prevent acceptance of this additive when zinc was present.

A striking example of the rapidity of X-ray analysis occurred one afternoon. A large national airline reported that one of its planes was having difficulty and it was suspected that the TEL content of the gasoline was off-specification. Nine gasoline samples were forwarded to the laboratory and arrived at 3:30 p.m. X-ray analyses were completed before 5:00 p.m. whereas wet chemical methods would have required at least another day. With the X-ray technique, it was possible to furnish the airline with data which demonstrated that the TEL content met specifications. It was discovered later that the plane's ignition system was at fault.

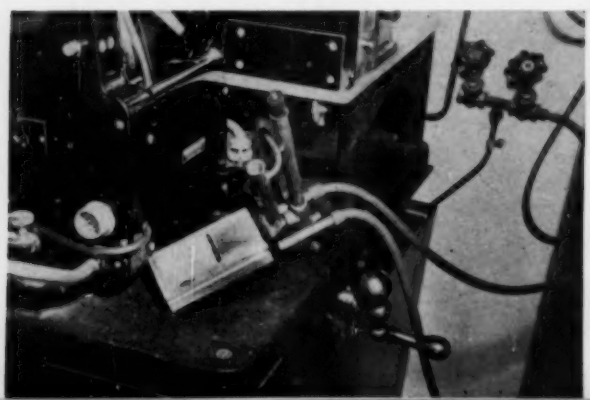
Still another analysis concerned identification of components for a heat exchanger. In storing stainless steel parts for this installation, two items of identical size and shape lost their identification tags. The laboratory knew the mixed components were made of different types of stainless steel — one contained nickel and the second had none of this metal. The X-ray Spectrograph determined the nickel-bearing stainless in a matter of minutes and the problem was solved conclusively and effectively.

The people who carry the responsibility for finding solutions for problems at Shell's Martinez refinery include: Bruno Stolley, refinery manager; R. F. Evenson, control laboratory manager; G. M. Brodrick, assistant control laboratory manager; Harvey Hook, supervisor, analytical section, and Maryalyce Myer, chemist.

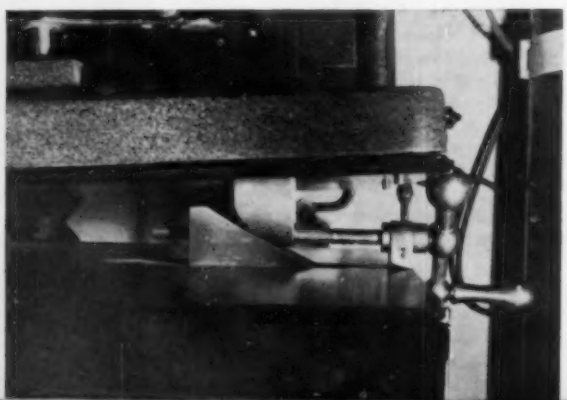
Refining is only one phase of Shell's vast and complex operations. First of all, oil is found by the exploration department. Then wells are drilled and crude oil is produced from them. Through pipe lines, barges or tankers, the crude oil is carried to the refineries, where it is transformed into useful products. Besides Martinez, Shell has refineries at Wilmington, California; Wood River, Illinois; Houston, Texas; Norco, Louisiana, and Anacortes, Washington. Finally, a huge transportation network brings these products to consumers of every kind.

To carry on these operations, Shell has invested an enormous amount of money in land, plants, machinery and many other kinds of equipment. Only the best of tools are provided to employees who keep this organization functioning smoothly — this is particularly true of the control laboratory where X-ray analysis instruments are performing more and more difficult tasks. ★ ★ ★

Close-up of water-cooled specimen cell developed for use in X-ray analysis work with gasoline.



Close-up for special device that permits adjustment of X-ray analysis unit to force bubbles out of sample cell.



California Crudes Show Great Variation in Properties

C. T. Brown
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Gravity, cetane number, metal content all have wide ranges

ALTHOUGH California crudes are generally known as asphalt-base or naphthenic crudes, these terms are only relative. There is considerable variation in crudes from the principal producing areas, with wide differences from field to field and even among zones in the same field, not only in terms of relative paraffinicity, but in product distribution and chemical composition.

The three general producing areas and their contribution to California's approximately 1,000,000 bbl per day production are:

(1) San Joaquin Valley. The 400,000 bbl per day produced in this area is predominantly 32-37-deg API gravity, of which Cuyama is typical. Crude from this area is the principal source for the San Francisco Bay refiners, with a lesser portion going south to Los Angeles.

(2) Los Angeles Basin's 315,000 bbl per day includes the Wilmington field, California's largest, which yields 111,000 bbl per day. Crudes from the several zones vary from 13 to 30-deg API gravity, with an average of 21-22 deg.

(3) The Coastal Area production is roughly 250,000 bbl per day, and here the Ventura Avenue field dominates the picture with 80,000 bbl per day of 30 deg API gravity crude. Low gravity, high sulfur crude makes up most of the 45,000 bbl per day production from the Santa Maria district, of which we have used the Santa Maria Valley field, yielding about 10,000 bbl per day, as a typical example.

Although the low wax content crudes, from which conventionally treated lube stocks may be produced without dewaxing, are of interest, we will not discuss them here because of the limited volume. They include Round Mountain, Santiago, and Poso Creek fields.

With such a range of crudes to evaluate, no one assay procedure is adequate for all. Not only are there many procedures from which to choose, but there are also many methods of reporting. Our selection should favor the method most apt to answer the largest number of probable questions. These queries generally concern either:

(1) Comparative data as a basis for crude oil exchanges, or
(2) Refining characteristics.

If we had only the first type of question, specific cuts and their properties would readily suffice, i.e.: 400 F endpoint gasoline, 100 Seconds Saybolt Furol viscosity at 122 F resid and the gas oil cut between, as shown in Table 1. Fig. 1 graphically shows the general relationship 400 F endpoint gasoline and 100 SSF viscosity at 122 F resid yields with gravity. It is evident that the difference of the sum of gasoline and fuel oil yield from 100 is the intermediate gas oil yield. It is also evident that given a crude gravity, a fair estimate of the yields of these three cuts can be made.

To supply information on refining characteristics, a greater variety of data is needed. The range of fractions in the solvent, naphtha, and middle distillate classes is endless and we have found that plotting yields and properties, as shown in the accompanying curves, is our best approach to answering the widest range of questions on a given crude.

The fractionation of these crudes is done in the Badger Column, commonly in use for referee crude oil exchange work. It is a glass batch still accommodating a 2-4 liter charge with a 48-in. by 1-in. ID packed column. When run at a rate of 8-10 ml per minute and an estimated reflux ratio of 6 or 8:1, the overhead temperature curve only approximates a "true boiling point curve," but since it correlates well with refinery crude processing units, it is suited to our purpose. A carbon dioxide trap follows the overhead receiver, condensing the light ends often reported as "distillation loss." The trap yield is added to our gasoline yield. The hydrocarbon analyses reported are determined on a separate distillation in which a sample of crude is charged to a Podbielniak column. An overhead fraction through C_6 is taken and is analyzed by the mass spectrometer.

Usually, 5 per cent fractions are taken on the Badger distillations, their properties determined and used as a basis for the overhead data, although cut points are often varied to give specific boiling ranges. The distillation is run at atmospheric pressure up to 500 F overhead temperature. At this point the flask is cooled and the dis-

EXCLUSIVE

tillation continued at a pressure of 10 mm mercury through the diesel range (about 650 F). If heavier gas oil or lube distillate fractions are desired, however, the 500 F bottoms are transferred to a metal still and column of similar design and the distillation continued at about 1 mm Hg pressure to a 20-100 penetration asphalt, as desired. By combining the 500 F+ resid from two or more atmospheric distillations, correspondingly larger volumes of the lube distillate cuts may be taken for small scale treating work.

The vapor temperature curve is drawn by plotting the overhead temperature directly against per cent distilled.

The properties of the overhead fractions are plotted on mid-per cent curves; for example, the sulfur content of the 20-25 per cent fraction is plotted at 22.5 per cent over.

The properties of overhead fractions are plotted as solid lines and normally include gravity, sulfur, aniline point, pour point, and Universal viscosities at 100 F and 210 F.

Resid properties are plotted on a "blend-back" basis and are shown by broken lines. Properties of any required yield or overhead temperature are read directly; that is, the properties of a 40 per cent resid yield are read at the 60 per cent over point.

Perhaps an illustration of the actual mechanics involved in obtaining data from which the "blend-back" curve is drawn is in order. In the case of the Ventura crude assay (Fig. 2), the yield of "Vacuum resid" was 19.38 per cent. By blending portions of this resid with aliquot parts of the two heaviest 5 per cent overhead fractions, we have a resid yield of 29.38 per cent and the properties of this resid are plotted at 70.62 per cent over.

We customarily tabulate some additional data on the crude itself and on specific fractions, such as gasolines of endpoints cut on the commercial units, a 650 F endpoint diesel and the vacuum resid. These are for ready use by the various recipients of the report, although much of the information can be read from the curves (see Fig. 2-7).

Specific examples of chart uses are as follows:

A. What will be the yield and properties of a 345-525 F kerosine distillate cut from Ventura crude? (see Fig. 2).

We note that 345 F and 525 F on the vapor temperature curve are at 28 and 45 per cent over, respectively, giving a yield of 17.0 per cent. The mid-point of this fraction will be $28 + \frac{17}{2}$ or 36.5. Consequently, we read our overhead curves at this point. We can see that such a fraction would meet the —40 F pour point requirement for JP-5, but would not meet a 20 mm smoke point, and that the mid-point of a fraction having a 22 mm smoke point would have to be reduced to about 30 per cent over, or 370 F mid boiling point to meet this requirement without resorting to treating.

B. If the properties of the reduced crude were required after the above 525 endpoint distillate, we read these from the blend-back curves at 45 per cent over. For example:

Yield, %	55
Gravity	17
Sulfur, %	1.35
Pour point, F	75
SSF viscosity @ 122 F	115

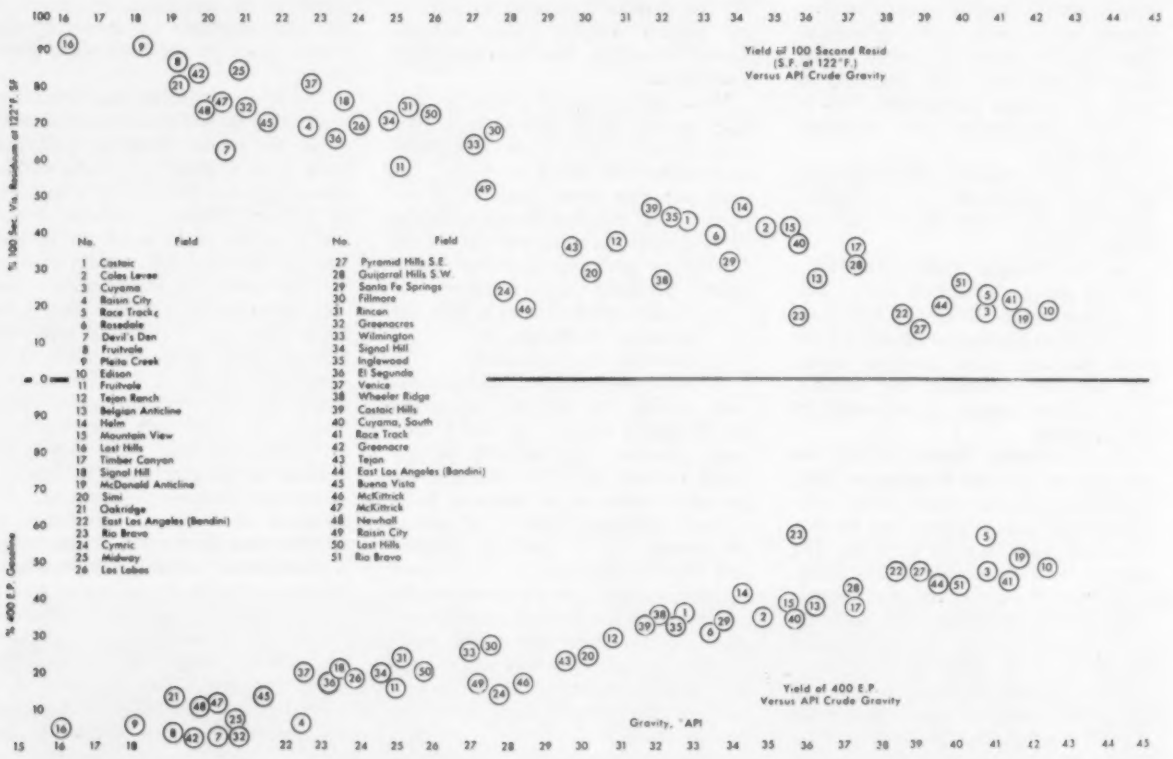


FIG. 1. General relationship between yields of 400 F endpoint gasoline, and 100 SSF (122 F) viscosity residuum with crude gravity.

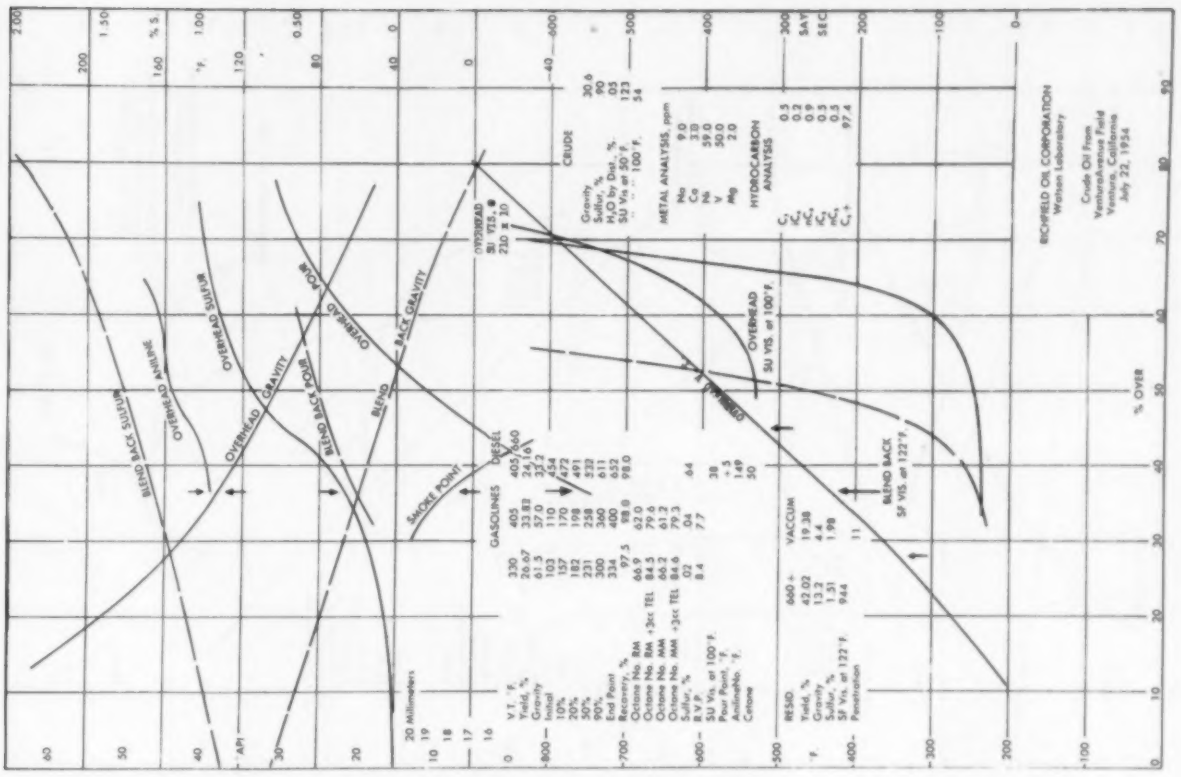


FIG. 2. Assay data on Ventura Avenue crude.

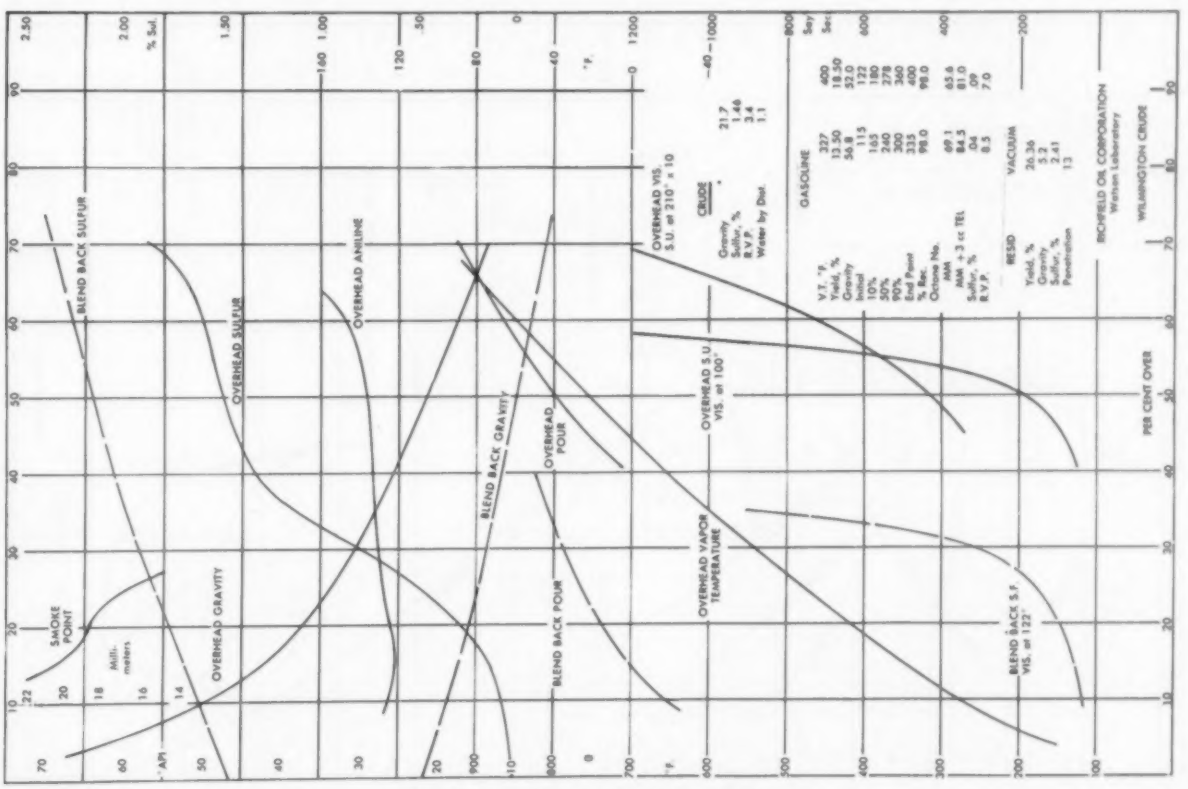


FIG. 3. Assay data on Wilmington crude.

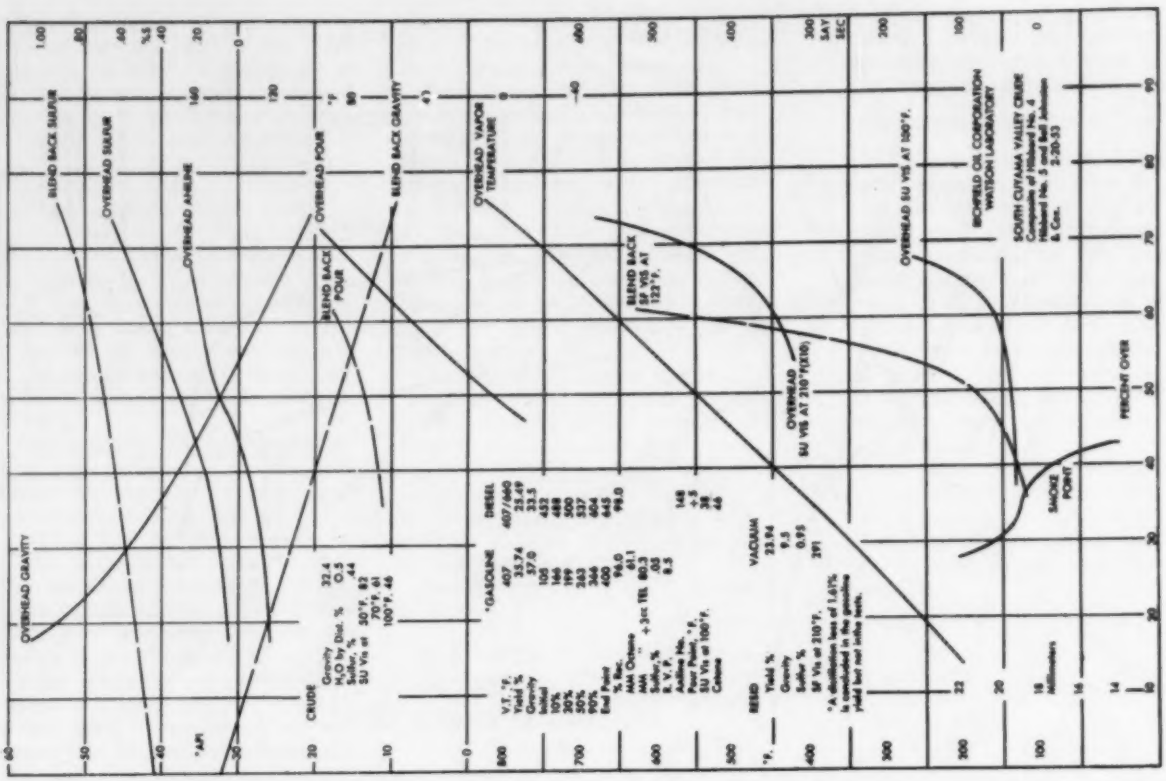


FIG. 4. Assay data on South Cuyama Valley crude composite.

FIG. 5. Assay data on Santa Maria crude.

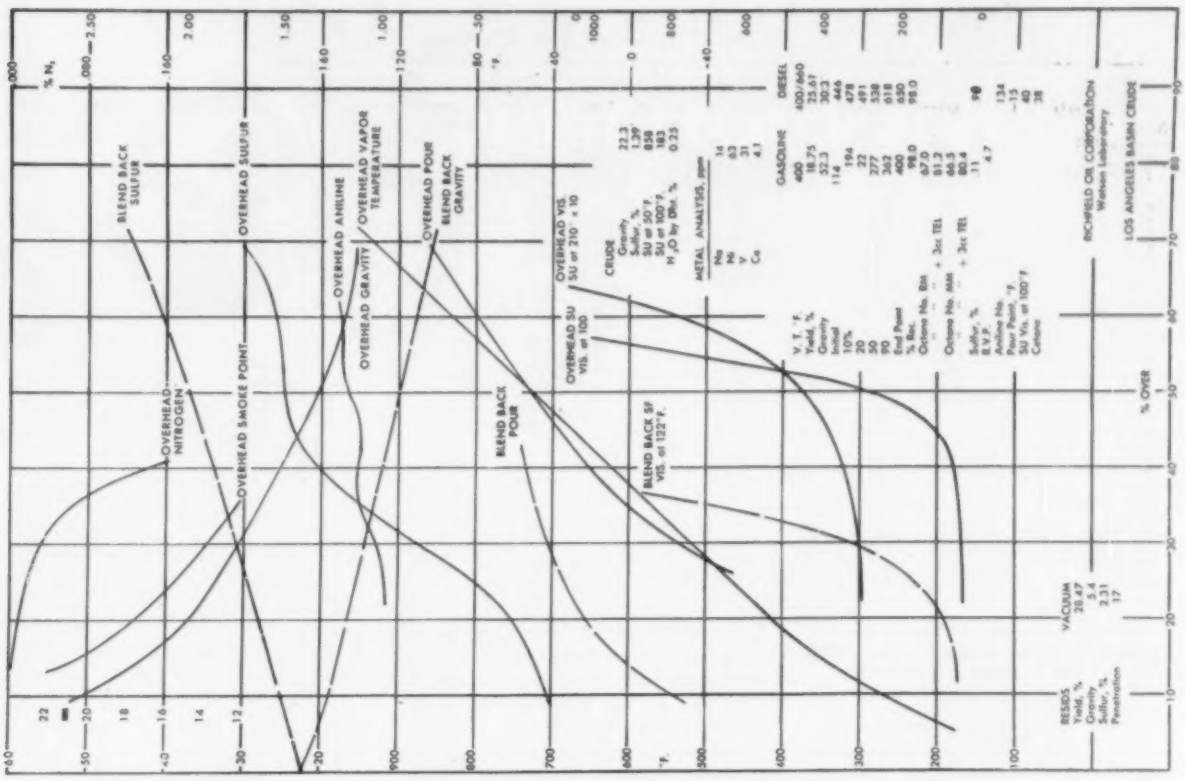


FIG. 6. Assay data on Los Angeles Basin crude.

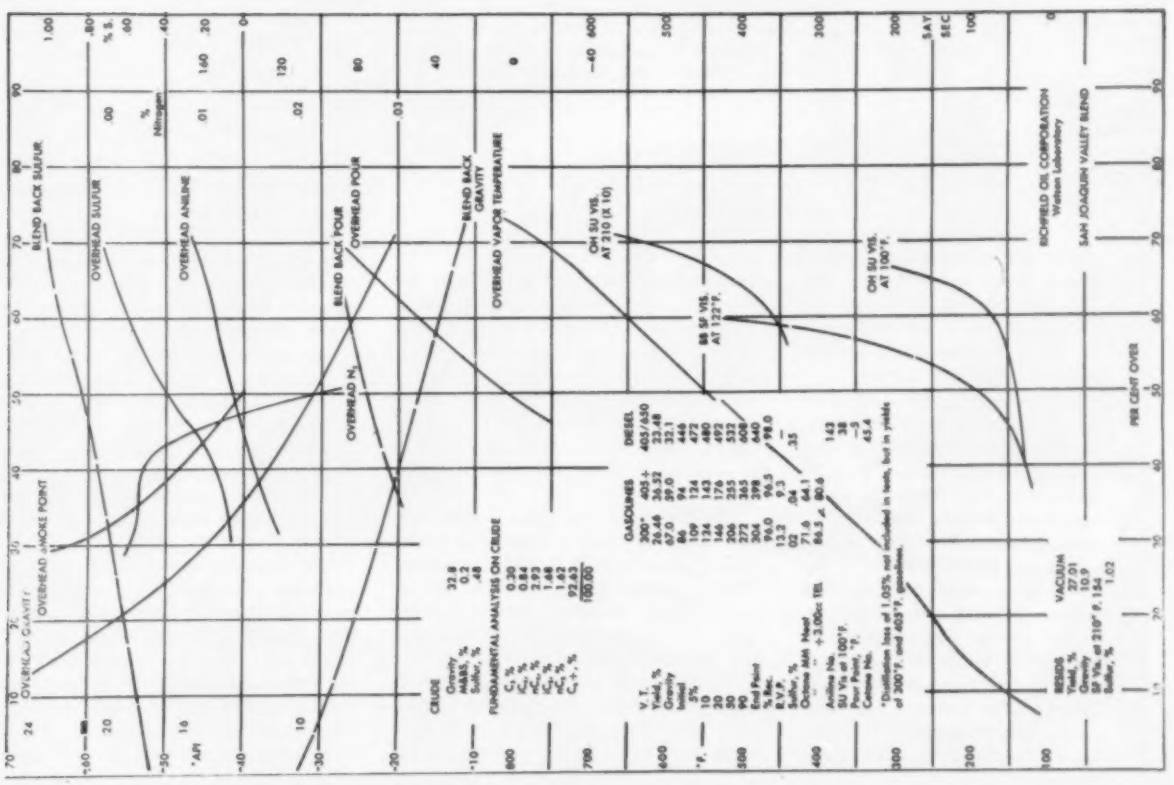


FIG. 7. Assay data on San Joaquin Valley crude blend.

TABLE 1. "Three cut" crude oil comparison.

Crude	Athens	Ventura	East East Los Angeles	Wilmington	Wilmington	Cymric	South Coles Levee	Cuyama	Huntington Beach	Tejon	South Cuyama	Santiago	Elwood	Wilmington
Gravity, °API	33.3	30.9	35.2	25.2	22.8	33.6	38.5	34.5	20.9	24.9	31.5	21.2	38.3	15.5
Sulfur, per cent	0.27	1.00	0.42	1.14	1.14	0.32		0.35	1.12	0.36	0.42	1.22	0.28	1.95
Cut No. 1														
Yield, per cent	34.79	32.21	36.40	23.21	18.96	39.83	45.40	36.87	18.88	15.78	32.18	19.24	46.00	8.07
Gravity, °API	54.3	57.4	55.4	53.8	53.2	52.4	56.9	57.5	51.6	50.0	56.4	50.0	55.7	47.4
Initial, deg F	110	102	105	116	116	134	106	94	116	112	98	124	108	166
10%	184	166	175	193	192	200	161	159	201	192	172	208	170	257
50%	271	261	268	275	280	273	250	260	278	292	265	283	267	317
90%	365	362	364	362	365	362	359	365	365	367	368	364	365	372
End point	400	400	400	400	400	400	400	400	400	400	400	400	400	400
Per cent recovery	97.5	97.0	97.5	98.0	98.0	98.0	98.0	97.0	97.5	98.0	96.5	98.0	98.0	98.0
Sulfur	0.03		0.04	0.07	0.08			0.04			0.03	0.15	0.04	
Octane MM	60.6	60.8	58.2			56.1		61.1	64.2	64.3	62.0	69.2	57.3	
Octane MM + 3ml TEL	77.3	78.2	77.5			75.0		80.7	78.8	81.4	79.4	80.8	97.3	
Cut No. 2														
Yield, per cent	28.22	11.65	25.90	9.01	5.21	28.42	23.13	20.56	−5.12	28.84	14.74	−2.75	22.50	−10.00
Gravity, °API	33.4	37.1	34.2	36.4	36.4	32.5	34.4	34.6		30.1	35.9		36.5	
Initial, deg F	444	430	443	419		434	433	442		454	433			
10%	473	453	479	436		481	466	471		485	456			
50%	523	476	523	450		530	512	509		536	480			
90%	602	522	598	485		613	586	569		605	537			
End point	640	560	636	518		646	620	602		646	576			
Sulfur, per cent	0.23	0.41	0.28	0.33	0.27	0.19		0.22		0.17	0.18		0.08	
Aniline	147	144	148	134	130	138		145		140	144		148	
SU viscosity at 100 F	37	34	37	33		37		36		39	35			
Cetane	49.3	48.3	49.9			47.9				45.6	47.6			
Pour point, deg F	+10	−25	+5	−60		+5		−5		−5	−25			
Cut No. 3														
SF viscosity at 122 F	100	100	100	100	100	100	100	100	152	100	100	125	100	214
Sulfur, per cent		1.50	0.83	1.51					1.70	0.87	0.71	1.38	0.54	
Pour point, deg F		70	+85	+50					+50	+75	+80	+15	+90	

TABLE 2. Motor method octane rating of 400 F endpoint gasolines.

	Crude gravity, °API	MM octane		
		Neat	+3ml TEL/gal	Susceptibility
Alison Canyo	24.4	74.2	87.0	12.8
Athens	33.2	60.6	77.3	16.7
Belridge	39.3	58.7	79.2	20.5
Buena Vista	28.5	70.4	82.8	12.4
Coaling Nose	30.2	60.0	78.0	18.0
Coles Levee	36.2	62.8	80.2	17.4
Elwood	33.4	45.6	66.7	21.1
Huntington Beach	20.9	64.2	78.8	14.6
Kettleman Hills	37.3	55.2	77.1	21.9
Mountain View	32.3	61.8	80.0	18.2
Paloma	46.1	63.0	80.8	17.8
Placerita	18.4	71.0	81.9	10.9
Santa Fe Springs	32.7	59.0	77.2	18.2
Santiago	21.0	69.2	80.8	11.6
Signal Hill	27.9	59.5	76.4	16.9
Ventura	30.3	59.1	74.6	15.5
Wilmington	29.2	56.0	74.5	18.5
Wilmington	20.4	67.2	81.4	14.2

C. In a similar manner, from the overhead viscosity curve the data of any given viscosity lube distillate can be read. Universal viscosities at 210 F are multiplied by 10 so that one scale suffices for all the viscosity curves.

D. A comparison of the properties of specific fractions of Wilmington (Fig. 3) and South Cuyama (Fig. 4) crudes shows that in addition to varying yields, gasolines from Wilmington will have higher octanes. The lower aniline points and lower gravities of the Wilmington fractions indicate poorer burning oil properties. Lower cetane diesel stocks are similarly indicated, although lower pour points are obtained. When sulfur contents are compared, the Wilmington fractions are seen to be appreciably higher throughout.

Indicative of the variation of crudes from field to field, Table 2 shows the range of Motor Method octane ratings of 400 endpoint gasoline, neat and with 3 ml TEL per gal. Susceptibilities range from approximately 11 to 22.

Selected cetane ratings of 400/650 F diesel fractions, to show further the variation of California crudes, are given in Table 3. Pour points are also included as a matter of interest.

TABLE 3. Variations in diesel (400/650 F) fractions from various fields.

	Cetane No.	Pour point °F
Cuyama	47	−10
Elwood	55	+10
Lost Hills	39	−90
Rio Bravo	52	+ 5
Santiago	34	−90
Wilmington (27.4°)	45	0
Wilmington (18.1°)	36	−60

Interest in the metals content of crude oils has developed greatly in the past few years. Nickel, vanadium and sodium are of particular concern as they might affect cracking catalysts. Sodium and vanadium are of concern in residual fuels because of their corrosion characteristics in gas turbines, as well as in other high temperature operations.

The tabulation in Table 4 indicates the range of these elements in California crudes. Nickel and vanadium values remain quite constant for a given crude whereas sodium values vary with the effectiveness of dehydrating and desalting operations.

California is also endowed with a number of fields producing 8-15-deg API gravity crudes, with sulfur contents ranging from 4-5 per cent. Best utilization of these crudes is a challenge to West Coast refiners. Fig. 5 shows the properties of such a crude. Of passing interest is the relatively high vanadium content (190 ppm).

TABLE 4. Partial metal analysis (parts per million).

Field	Sodium	Nickel	Vanadium
Arvin	4	28	9
Coal Oil Canyon	4	20	6
Coles Levee	4	31	11
Cuyama	31	32	10
Cymric	46	43	30
Edison	51	11	6
Helm	77	27	14
Kettleman Hills	18	24	11
Lost Hills	35	80	39
Raisin City	34	21	8
Russell Ranch	4	26	12
Santa Maria	20	106	180
Signal Hill	25	57	25
Tejon Hills	7	44	64
Ventura	70	51	42
Wheeler Ridge	2	19	7
Wilmington	5	61	43

With such a variety of crudes, it is only natural that many are segregated for the production of specific commodities. One attribute of some of the heavy, high-sulfur crudes is the superior quality of some oxidized asphalt products. From the refiner's viewpoint, however, the bulk of pipe line crudes are mixtures, varying little from month to month or even from year to year. Hence, our consideration of the Los Angeles Basin mixture and the San Joaquin Valley blend, assays of which are reported in Fig. 6 and 7.

We have presented a method of crude oil evaluation that we believe is versatile and of rather wide application. Specific properties may be added or deleted as interests change. Only the most optimistic will ever hope to answer all questions that might be asked about a given crude. Recently, after a most complete analysis, the first question was, "What is the arsenic content of the 300-400 naphtha?" ★ ★ ★

THE Case OF THE RECALCITRANT TUBE

FACTS: High pressure, high temperature refinery application (hydrogenation of petroleum)
Tubing in question was stainless type 347
Tubing met original specification for job

CLUES: Tubing was in service for about 100 hours at a pressure of 10,000 psi and a temperature of 1100 F, before failure.

EXAMINATION REVEALED: Temperatures and/or pressures used in actual testing or operation exceeded the original specifications

Failure resulted from progressive wall thinning due to creep

POSSIBLE SOLUTIONS: Change operating conditions
Use a thicker wall tube. Change tube material

B&W SUGGESTION: When it comes to choosing a tube, consider *every* factor involved, including possibility of exceeding current service conditions. *And* get the benefits of Mr. Tubes' long experience with tubing for every kind of application. He knows his tubes—what they will and what they won't do. Call him in at any time. He's as close as the phone at your elbow.

B&W TUBULAR PRODUCTS DIVISION

TA-5066 P

THE BABCOCK & WILCOX COMPANY
TUBULAR PRODUCTS DIVISION, BEAVER FALLS, PA.

Seamless and Welded Tubular Products, Seamless Welding Fittings and Flanges—in Carbon, Alloy and Stainless Steels

P 773.1

MECHANICAL ENGINEERING

Plant Layout Principles Are Fundamental Factors in Fire Protection, Safety

Don Attaway
Arkansas Fuel Oil Comany

GENERALLY, the layout and location of operating units within a natural gasoline plant is determined primarily by the design engineers for efficient performance, economic construction, and future expansion. It would be most commendable if all oil and gas operators had laid out their gasoline plants according to the best advice of safety authorities. Unfortunately this has not been done in many cases. As a result many plant areas have reached conditions that are clearly hazardous, but whose correction is virtually impossible. The condition is even more acute where such plants are near large cities or adjacent to main water or rail transportation centers as well as residential sections.

The author will make no attempt in this article to outline remedies for such conditions, but would suggest that corrections be made, where possible, in the course of normal plant repair and replacement. This article, therefore, will be devoted to the discussion of the safety aspects of good layout practices in equipment spacing for new installation and existing plant expansion.

Basic Layout Requirements

Adherence to certain spacing fundamental requirements makes any gasoline plant safer and more efficient. In any plant handling flammable materials, the first consideration must be fire prevention and protection. The following basic rules should be observed:

1. Separate elements, such as process units, storage tanks, steam plant, etc., must be sufficiently spaced so that fire in one element will have a minimum effect on nearby equipment.

2. Critical units, such as a single important element upon which the entire plant operation depends, must be given the maximum protection.

3. Highly hazardous areas must be separated by sufficient distance from other parts of the plant.

4. Plant utilities, such as steam, electric power, and water, must be protected from the effects of accidents elsewhere, so that they may be maintained at all times even when emergencies exist.

5. Provisions must be made for proper drainage as protection against flooding the vital areas from any cause.

6. Consideration must be given to general climatic conditions such as prevailing winds, frequency and velocity of windstorms, extent of rainfall, and even earthquake.

7. Special consideration must be given to installations and occupancy on lands adjacent to the plant site including pipe line right-of-ways, highways, railroads, residences, and such.

8. Proper allowance must be made for convenient roadway entrance and exit as well as access under emergency conditions to all portions of the plant.

9. Proper supervision of all plant entrances must be made.

Object of Spacing

These nine requirements relate essentially to spacing and location. The establishment of minimum distances between operating units as well as location of other plant elements has long been a problem of serious concern to safety authorities, the gas and oil industry, and insurance underwriters. An important consideration in determining fire risk is "degree of exposure," which is the extent of hazard of ignition for a unit or its contents from a fire in an adjacent location.

The object of spacing, therefore, is to reduce the spread of the fire to other units. The spread of fire damage develops from the direct effect of heat on other equipment or by the ignition of flammable gases, solids, or liquids as a result of the heat, spread of flames, or travel of sparks and missles. In natural gasoline plants, there is a hazard even more dangerous than exposure to fire damage. It is the serious possibility of violent explosion.

It is true that no single definite recommended spacing schedule for present day installations is available, however the American Petroleum Institute compiled a manual titled *Fire Protection In Refineries* as far back as 1941 that contained a basic schedule used occasionally today. It is admitted to be somewhat obsolete, however, and is in the process of revision.

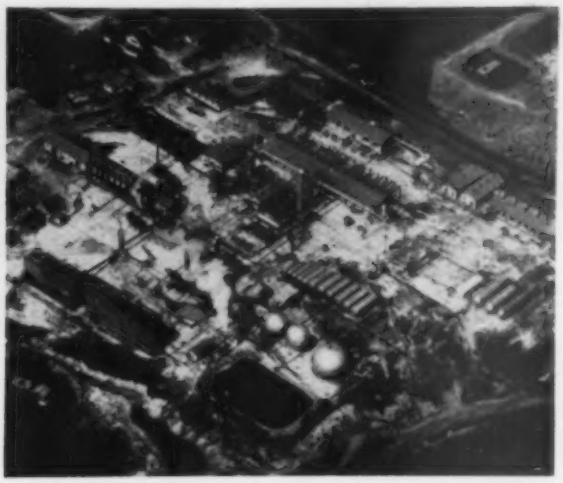
Even the U. S. Bureau of Mines published Technical Paper No. 462, entitled "Safety at Natural Gasoline Plants," by G. B. Shea that gave consideration to critical conditions such as hazardous vapor areas and contour of the plant site in relation to the location of equipment that listed minimum distances. Some of these distances were not entirely in agreement with the API schedule.

Consequently, the spacing of equipment has varied widely and resulted in contract construction firms spacing for economy's sake, design engineers locating for efficiency's sake, and neither giving true value to safety in many instances.

The results of a survey conducted by questionnaire is summarized in Table 1 showing this wide difference of opinion. This may indicate the futility of attempting to set-up fixed minimum distances for layout that would be acceptable to everyone. On the other hand, it may also

CUT ALONG THIS LINE FOR YOUR PERSONAL REFERENCE FILE.

Aerial view of a fairly well spaced natural gasoline plant, showing separation of units and isolation of ignition areas.



Example of a badly arranged and spaced plant, showing the effects of continuous expansion.

TABLE 1. Summary of spacing questionnaire natural gasoline plants.

FROM	To	Street, highway or property line (ft.)	Storage tanks (ft.)	Cooling tower (ft.)	Stills towers (ft.)	Absorbers, scrubbers (ft.)
(1) Street, highway, or property line						
minimum distance.		—	50	50	50	50
maximum distance.		—	150	100	150	150
average distance...		—	140	85	112	105
(2) Compressors, engines, pumps						
minimum distance.		20	50	20	25	25
maximum distance.		75	400	200	150	150
average distance...		49	235	63	75	75
(3) Boilers, heaters, open flames						
minimum distance.		25	150	25	75	150
maximum distance.		125	450	350	200	250
average distance...		65	310	155	145	195

indicate the crying need for a standard and signify that it is a possibility.

The author believes that it is entirely possible to investigate the practices of oil and gas companies that have low fire experience records, and to consult the best fire protection engineers and safety authorities in order to compile their facts and thinking into a definite pattern. After compiling this information and comparing it with the requirements set up by the different regulatory bodies such as the Fire Underwriters, National Fire Protection Association, Liquefied Petroleum Gas Association, and others; a spacing schedule with some flexibility can be established.

Equipment Spacing

The spacing schedule shown in Table 2 is the result of such a combination and in the author's opinion is suitable and acceptable for the natural gasoline plants. The distances are the minimum number of feet desired between the nearest major element of each unit and are not center-to-center distances. The distance requirement means separation of units; not elements within the unit. All five columns should be considered in spacing but the "exposed" flame or greatest distance should govern.

For the units listed, the distances shown under open flame exposure refer to separation of that portion of the unit where flammable liquids are present, from the location of another source of ignition such as boiler, furnace, etc. Where immediate control in extinguishing furnace fires under emergency conditions is provided, the distances may be less.

It is recognized that plant locations in certain areas must abide by city, county, or state minimum distance regulations and the spacing shown is not intended to replace or contradict such regulations.

Area Separation

From a fire prevention standpoint, the natural gasoline plant can be divided into three distinct areas.

(a). **The operating area,** in which the equipment has no open flame present. This area usually has both flammable liquids and gases present in confined vessels or tanks as well as open to atmosphere. Leaks, spills, overflows, and normal draining during operation provides the presence of these vapors. This section of the plant must be free from any source of ignition. No smoking is the rule in this area. Outside of electrical circuits, static electricity, and lightning, nothing should be present that will ignite vapors.

(b) **The ignition or "open flame"** area is composed of equipment that inherently has heat sufficient for ignition, either in open flame, stacks, exhausts, or sparks. Smoking is usually permitted in this area. It logically follows that there must be no flammable liquids or vapors present, either confined or in air.

(c) **The storage area** should have neither flammable vapors in quantity nor source of ignition.

TABLE 2. Minimum distances between plant equipment units. (Feet)

Equipment	To a similar unit	To another operating unit	To any product storage	To any continious open flame	To street, highway or property line
OPERATING AREA					
Absorber	NL	50	75	150	50
Separation scrubber...	NL	50	75	150	50
Still (1)	25	25	75	100	50
Fractionator (2)	25	25	75	200	50
Pump house	NL	50	50	200	50
Cooling tower	NL	75	100	100	25
Treating (gasoline)...	50	50	75	150	50
Blending (gasoline)...	50	100	100	200	50
IGNITION AREAS					
Compressor building..	25	75	75	200	25
Boilers	NL	100	100	NL	50
Direct-fired heaters...	NL	100	100	NL	50
Flares	NL	100	200	NL	100
Auxiliaries	NL	100	100	150	125
Truck loading rack...	NL	100	100	200	100
Tank car loading rack.	NL	100	50	200	100
Buildings-office, lab...	NL	100	100	NL	25
STORAGE AREA					
Atmos. tanks (up to 50,000 gal) (3)					
Atmos. tanks (over 50,000 gal) (4)					
Pressure tanks (up to 10,000 gal) (5)					
Pressure tanks (10,000 to 100,000 gal)					
Pressure tanks (over 100,000 gal)					

(1) where feed stock is liquid at atmospheric conditions.
(2) where feed stock is not liquid at atmospheric conditions.
(3) Atmospheric pressure up to 5 lb.
(4) Distance shown or diameter of tank, if larger.
(5) Tanks such as accumulators, are integrals of a unit-no storage tanks NL indicates no limit or maximum.

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FIG. 1503—150-Pound Steel Gate Valve.

FIG. 6003—Steel Gate Valve for 600 Pounds W.S.P.

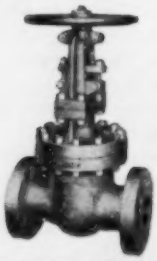
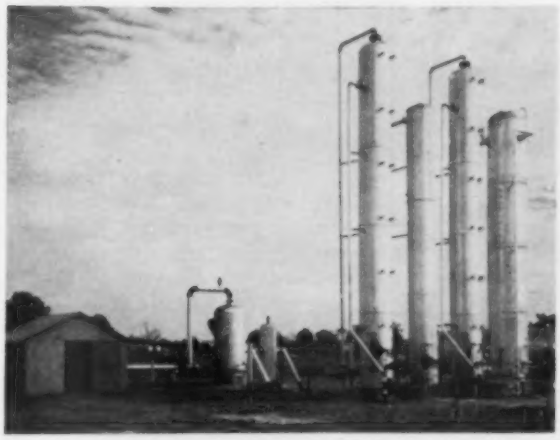


FIG. 6061—600-Pound Steel Swing Check Valve.

POWELL VALVES

BRONZE, IRON, STEEL AND CORROSION RESISTANT VALVES.



Typical absorber battery, well spaced, showing scrubbers and metering station.

These three areas would be separated and isolated in the ideal natural gasoline plant.

Operating Area

Absorbers. The interest of safety and utility is best served when absorbers are located on the down flank of an elevated ridge when the boilers, fired heaters, and compressors can be placed on the other. Likewise, absorbers are often installed as a battery of two or more with a high degree of safety. It is logical to fix 150 ft as a minimum distance between absorbers and any continuous exposed flame, based on the opinion of all plant operators consulted. A greater distance would not insure complete safety, but a shorter distance is certainly considered dangerous.

In view of the fact that scrubbers and separators are an adjacent and integral part of the absorber unit, they would abide by the same rule.

Stills, Fractionators, Etc.

The distillation and fractionation units of a plant provide the area in which much of the flammable material of the plant is present. With possibly the exception of the storage area, the bulk of the liquid fuel and vapors are continuously present in this area. These units may be well located in low spots in the plant, so that any break or leak will not drain toward a source of ignition such as a boiler, direct-fired heater, or compressor building. Stills and their contents are not as volatile as fractionators and therefore should be 100 ft or more from any continuous exposed flame. The vapor content and higher pressure of fractionators demand that they be 200 ft for an open flame.

Pump Houses

Pump houses handling flammable liquids present much the same hazard as the distillation area. Usually the pumps are an integral part of the distillation and fractionation units. They lack the storage content of vessels and tanks and can usually be shut off in case of break or leak, although their contents are often identical or equally as volatile and flammable as the process unit material. They present a hazard equal to any continuous exposed flame and should therefore warrant the minimum spacing of 200 ft from such a source of ignition.

Treating and Blending

These operations are not present in all natural gasoline plants. In some plants acid treating may be present and continuous. In others lead blending may be in operation only part time. These operations present a liquid and vapor fuel hazard to a large degree. Lead suppliers often specify the spacing distances for this operation and their distances should be the rule. Their greatest exposure is an open flame and treating operations should be 150 ft away, while blending of volatile liquids should be at least 200 ft from any continuous exposed fire.

Cooling Towers

The belief that a cooling tower is not subject to fire is highly erroneous. Many water cooling towers have been completely destroyed by fire. This is explained by the fact that plant cooling water is often contaminated by gasoline and oils from leaks in coolers and condensers. This highly flammable material saturates the tower structure and accumulates on the surface of the water in the basin where the smallest spark or flame may ignite it.

Cooling towers should be located on the highest crest in the plant, but not nearer than 100 ft to any continuous exposed flame. Mist and water vapor from towers has a very costly corrosion and rust effect on immediately adjacent metal equipment and should never be so located.

It is generally agreed that both forced draft and atmospheric type towers fall in the same category where considered for spacing.

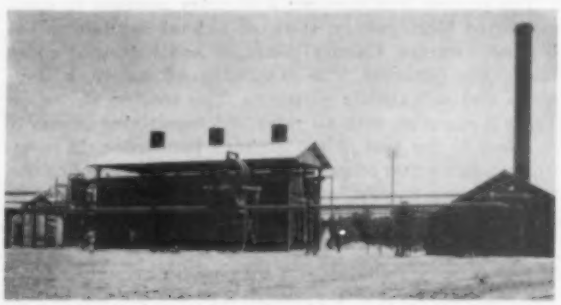
Ignition Area

Compressors. Compressors, powered by gas engines, should not be located in low spots with reference to the rest of the plant. They are best located near the crest of a ridge or on a rise in elevation. An ideal location would be the boiler plant, compressor room, and cooling tower on the crest of separate ridges. Compressors are a secondary source of ignition as well as an area where flammable vapors may be intermittently or continuously present. They present a potential explosion hazard and therefore warrant the minimum 100 ft of spacing from the process area of the plant.

Auxiliaries—Air, Electricity, etc. The plant utilities, such as the electrical generator room, air compressor, etc., are key points in a plant and should be kept at safe distance from the process area. Damage to the electrical source or circuit to or within a plant can shut it down. Such auxiliary installations should be 100 ft or more from the process area. A general and safe spacing practice is to locate these units in the same general area as the compressors.

It is highly desirable to keep all electric power lines and poles as remote as possible from the process area. Circuits handling 220 volts or more are especially hazardous within 50 ft or less. Electric wires provide not only a source of ignition but, if broken or fallen, may energize all metal parts of the plant exposing personnel to shock and electrocution.

Boilers and Direct Fire Heaters. Boilers and direct-fired heaters are the primary ignition source in any plant as



A well-spaced arrangement of a direct-fired heater and boiler house; boiler feed pump house is at extreme left, boilers in center, heater at right.

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they provide a continuous exposed flame. They should be on the windward side of the plant, not less than 100 ft from any other operating unit, and on the opposite side of the plant from the storage area by at least 100 ft. Fire stills, and direct-fired heaters may, however, be placed near boilers as a safety precaution as well as a convenience. Boilers and heaters should never be located at low spots with reference to the rest of the plant.

Flares. The day of the large plant flare has passed due largely to the rules of conservation. There are, however, some undesirable and waste gases present in many plants that must be consumed. Such flares should receive maximum isolation whenever possible and be at least 200 ft away from areas where vapor and liquids are constantly present. No flare should be closer than 100 ft to any operating unit of the plant regardless of its make-up. The plant flare should receive the greatest spacing possible, when it is used for plant blow-down or emergency relief. In such case, it should be considerably more than the distances given in the table up to 500 ft or more, where large quantities of gas or liquid are involved.

Loading Racks. Most gasoline plants have either a tank truck or a tank car loading rack while many others have both. The hazards in each case are almost identical, however, the extent and degree of exposure is different. In tank truck loading, each truck that enters to load or unload brings a potential source of ignition from either engine exhaust, electrical systems, or static. Sometimes hundreds of trucks visit a loading rack daily. The railroad or tank car rack is not visited as ofter by steam engines, locomotives, or diesels and consequently does not have an equal exposure.

The Association of American Railroads has set up definite spacing relative to loading racks and railroads. Briefly, racks that load up to 16 lb vapor pressure products must be 50 ft from the tracks and racks loading products over 16 lb vapor pressure must be 100 ft from the tracks.

Loading racks have the inherent hazard of flammable vapors and should be at least 200 ft from any continuous exposed flame.

Office and Buildings. In general, buildings housing personnel such as an office, warehouse, or laboratory should be placed reasonably close to the plant entrance, but outside the operation danger zone and on the side opposite the plant storage. Likewise they should be so located that it will not be necessary for personnel to walk or drive through the process or storage area to reach them. The inherent danger of smoking and motor car exhaust is ever present.

Offices and laboratories usually have open flames and provide a source of ignition for vapors or gases released in the plant and therefore should be at least 100 ft from the operating area.

Storage Area

The storage area presents a complex problem in spacing. Often local, county, state, or federal regulations list specific distances. Certain insurance and industrial codes also define distances. The Association of American Railroads also sets certain distances. The spacing shown on Table 2 complies with all rules and regulations generally in effect to the best of the author's knowledge. It is entirely possible that other codes or rules with conflicting distances govern specific locations and areas. This should be determined before laying out a plant storage area.

Firewalls and Fire Lanes. Fire walls or dikes are considered necessary around practically all tanks. Their main function is to hold any overflow, leakage, or spillage, but they also protect tanks from the spread of burning liquids and flood waters. The API and NBFU codes specify the details of firewall construction, but generally they must be 3 ft or higher and so located to retain the contents of the tank.

Location of this storage area isolates it from the main plant, by the cooling tower placed between, is another example of proper arrangement and spacing.

High firewalls have been found to be a serious disadvantage in fire fighting, stopping leaks, and even ordinary maintenance.

Recently plant operators have found the diking of butane-propane storage areas a valuable protection against spread of burning liquids, encroachment of flood waters, as well as accidental entry or collision by vehicles. Where aggregate storage is 5000 bbl or morein a single plot, the entire group is usually enclosed by dike so that there will be a great diffusion into the air of any spillage or break and thus reduce the hazard.

Most plants are subject to encroachment of fire from outside sources. This is especially true of isolated rural plants in wooded areas where forest and grass fires occur. A standard practice is the cutting of a fire lane around the plant proper. Turning plows and discs are often used twice a year or more to retard growth of vegetation. Weed and vegetation killers are also used in many localities where growth is prolific. These fire lanes should never be less than 20 ft in width. Where trees and shrubbery are present the width should be materially increased to prevent flames leaping the firebreak.

Conclusion

Radical changes in natural gasoline plant layout and spacing have been made during the past ten years. Newer materials and processes as well as better and more effective fire extinguishing agents and methods have been developed.

When these advantages are combined in the modern day plant erection, the economy of first cost and maintenance as well as safety and convenience are automatically present. The trend today should be to plan the plant for safety first and the other advantages will follow. Engineers and designers will do well to consult a qualified fire protection or safety engineer while their plants are in the planning or blueprint stage to prevent building a death trap for humans and a catastrophe for stockholders.

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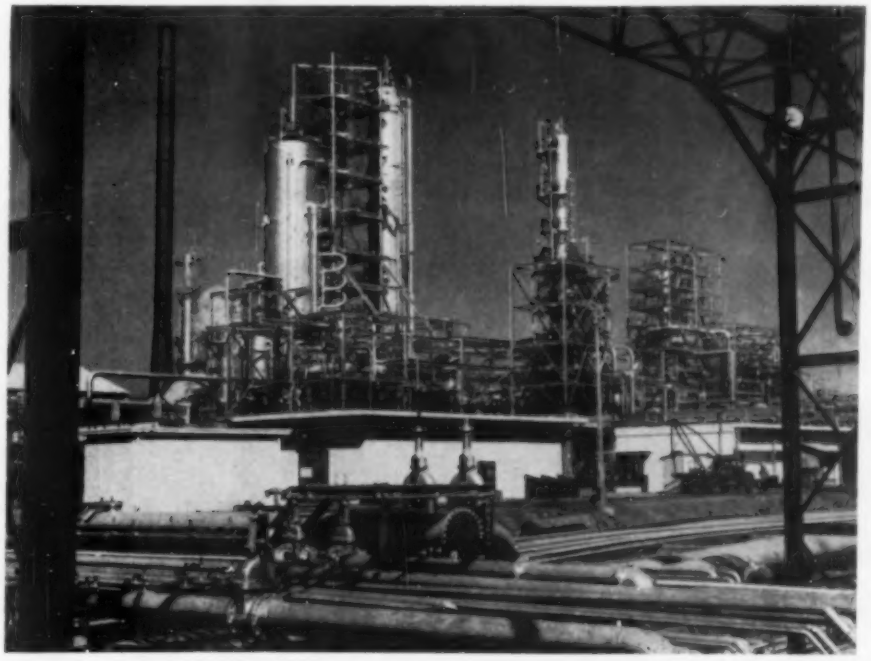


FIG. 1. "Heart" of the Bombay refinery—crude distillation unit, which handles nearly 44,000 bbl per day of tanker-transported crude. At right, cat cracker feed preparation unit.

Largest Indian Refinery on Stream

Burmah Oil-Anglo-Saxon's Bombay refinery cost $64,000,000; to process 14,600,000 bbl per yr; shows new highs in operating efficiency

C. Morgan Jones
European Correspondent

INDIA'S largest oil refinery with an annual capacity of 14,600,000 bbl of crude (2,000,000 metric tons) is in full operation. Located at Trombay Island in the Bombay harbor area, its total construction costs exceeded $64,000,000.

Built by Burmah-Shell Refineries, Ltd. (Burmah-Oil Company, Ltd.), and the Anglo-Saxon Petroleum Company, Ltd. (a Royal Dutch-Shell group company), products from the refinery will be marketed by the Burmah-Shell Oil Storage and Distributing Company of India, Ltd., which is also jointly owned by Burmah-Oil Company and the Anglo-Saxon Petroleum Company.

General Refinery Flow

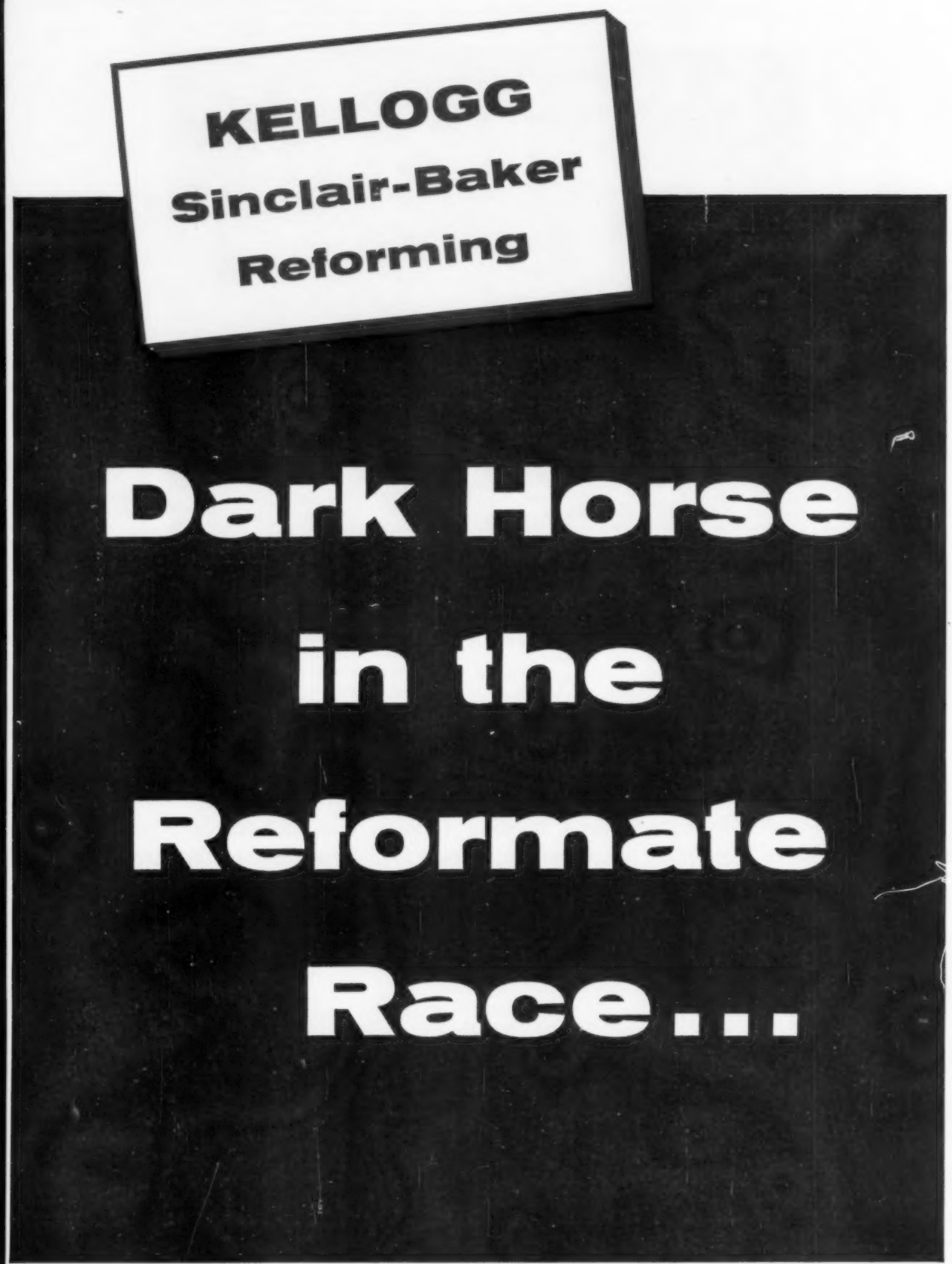
Crude oil for the refinery arrives in tankers that unload at the newly constructed Butcher Island Marine Terminal. Crude is then pumped through underwater pipe lines to the tank farm.

From the farm, the crude is charged to the distilling unit, which produces both intermediate and finished products. The straight-run gasoline and kerosine are finished by chemical treatments; light and heavy gas oils are used for the middle distillates; while the long residue is charged to the vacuum flashing unit, which provides the charging stock for the catalytic cracking unit.

In addition to cat-cracker feed, the vacuum flasher unit produces short residuum part of which is passed to an asphalt-blowing plant. The balance is used either as refinery fuel or as a fuel oil component.

The waxy distillate fed to the catalytic cracking unit is converted into gas, cat-cracked gasoline, light and heavy catalytic gas oils, and coke. Coke formed is consumed in the process. Gas and gasoline then pass through the compression system to the fractionating columns of the gas-recovery section. Part of the gas is used as a refinery fuel while the gasoline is charged

EXCLUSIVE


KELLOGG
Sinclair-Baker
Reforming
Dark Horse
in the
Reformate
Race...

New Process and New Catalyst Promise New Records in Production of Low Cost, High Octane Reformates

Although the M.W. Kellogg, Sinclair-Baker process is still too new in service to provide any long-term performance data, and customers' initial findings cannot yet be disclosed, many economic advantages of this catalytic naphtha reforming process have already been firmly established. Any refiner faced with increasing octane yields from present feedstocks, or with getting high octane reformates from lower grade naphthas, will recognize the significance of the following points . . .

Quick Start-Up

Experimental operation is reduced to a minimum. One M. W. Kellogg reforming unit was started on its final test run within two weeks after the catalyst was first charged to the reactors—with octane rating and yield during this 15-day period well in excess of the guarantee.

A Regenerative Catalyst

Sinclair-Baker Platinum Catalyst RD-150 can be regenerated easily and quickly *in situ* to provide many operating cycles, each of many months duration, with negligible loss in catalyst activity. Cost of catalyst per pound in terms of barrels of reformate produced is a major economic factor of the process.

Long Catalyst Life

Sinclair-Baker regenerative catalyst RD-150 has high activity and long initial life. It has been in operation for over one year without supplementing the catalyst. 95 octane reformate can be produced for six months or longer before regeneration is required.

Octane Level

Depending on the feedstock, clear octane ratings above 90 are now being obtained commercially—with 100, and even better, a goal that is entirely feasible and economically practical. *Variability* of octane rating is the keynote of the process, permitting selection of the exact processing conditions for a given naphtha to secure optimum economic operation at all times.

Supply of Catalyst

Use of the process does not obligate refiners to buy Catalyst RD-150 beyond the first year's requirements, although a continuing source of supply can be assured. This freedom from long-term purchase and license agreements is an important consideration when deciding which is the most suitable reforming process.

Low Grade Naphtha Feeds

M. W. Kellogg's unique design permits the effective desulphurization of low grade naphthas as part of the process, and avoids corrosion and metal contamination. Kuwait naphthas thus treated, for example, can produce yields of high octane reformates only slightly lower than those for higher grade Mid-Continent feedstocks.

For More Information

Further details on M. W. Kellogg's catalytic naphtha reforming process, the Sinclair-Baker catalyst, together with some economics of both, are contained in a recent booklet, "Low Cost Production of 95 Octane Clear Reformate." Copy sent on request.

Refinery Process Division

THE M. W. KELLOGG COMPANY

225 Broadway, New York 7, N. Y.

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to treating facilities. The light and heavy catalytic gas oils recovered from the cat-cracker product fractionator are blended into fuel oil.

Finished motor gasoline is prepared by first caustic scrubbing and sweetening the straight-run and cat-cracked components and then adding inhibitor, dye, and tetraethyl lead to the actual blends. The kerosine fraction from the crude distilling unit is acid treated to bring it up to marketing specifications.

Both white products and black oils are transferred by pipe line to two nearby terminals. Sewri, four miles away, handles automotive gas oil (diesel), kerosine, and gasoline. Wadi Bunder, a further three miles away, is restricted to handling black oils. Products are delivered from refinery by railroad tank cars.

Crude Oil Distilling Unit

The distilling unit is designed for an intake of 6000 metric tons (43,800 B/D) of Kuwait crude oil per stream-day. It consists of primary and secondary column, a stabilizer, and three strippers.

Crude oil is pumped from storage through several heat exchangers, partly vaporized in a furnace, and then charged to the primary column. Unstabilized gasoline is taken overhead, condensed, and fed to a stabilizer. This column produces 9-lb RVP gasoline as a bottom product, and the light hydrocarbons comprising the top product are routed to the refinery gas system.

Stabilized straight-run gasoline is caustic treated prior to being sweetened. Light kerosine is withdrawn as a side stream from the primary column and is stripped in the kerosine stripper.

The primary-column bottom product is further heated and then charged to the secondary column, which operates at 300 mm Hg absolute. In addition, stripping steam is injected. The overhead vapors pass to the vacuum system and are condensed, the water being drained and the hydrocarbon phase transferred to the kerosine stripper of the primary column.

Heavy kerosine is withdrawn directly as a side stream from the secondary column. Light and heavy gas oils are similarly withdrawn and are separately stripped. Light and heavy kerosine streams are run together to intermediate storage prior to being charged to the kerosine acid treater.

The light and heavy gas oils are cooled and sent to storage before being blended into middle distillates for sales. The long residue from the bottom of the secondary column after heat exchange with the crude oil is either fed hot to the vacuum flashing unit or is cooled and transferred to storage.

Cat-Cracker Feed Preparation

Vacuum flashing is used for the preparation of the cat-cracker feed stock from the long residuum.

The unit is essentially the same in design as those used in some of the European refineries of the Royal Dutch-Shell group.

Normally, long residue is charged hot from the crude oil distilling unit. The feed pumps of the feed preparation unit circulate the charge through internal vapor-to-feed exchangers, then through bottoms-to-feed exchangers, and finally through a heater and into the bottom of the flash tower. Here the pressure is 40 to 60 mm Hg absolute. The resultant flash vaporization produces the primary separation between the distillate and short residuum.

The vaporized distillate passes upward through demisters, which reduce the entrainment of the asphaltenes and metal contaminants in the cat-cracker feed. The residual material removed by the demisters is recycled to the feed line but part is cooled and recycled to the entrainment-removal plate, where

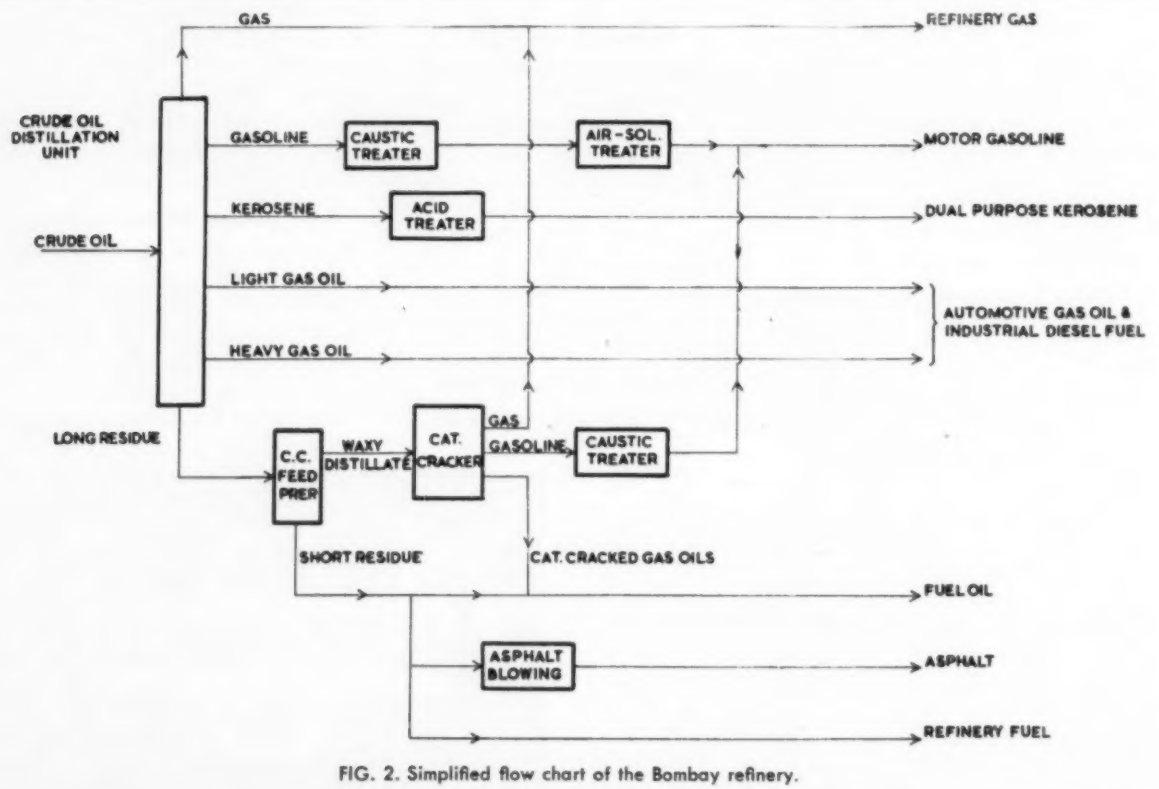

FIG. 2. Simplified flow chart of the Bombay refinery.

its washing action minimizes coke deposition.

Vapor leaving the demisters continues upward, past a top deck, through the flash tower, and then downward over the external vapor-to-feed accumulator.

This vessel also receives the liquid that condenses on both the tower walls above the top deck and the shell enclosing the internal exchangers and condensers.

Uncondensed vapor from the flash tower is sent to a condensing tower, where part of the vapor is condensed by contact with cooled condensate refluxed through the tower. This material is injected into the distillate from the accumulator and the combined stream either goes through hot to the cat cracker or is cooled before being transferred to storage.

From the top of the condensing tower, the remaining uncondensed vapor is withdrawn at 20 mm Hg absolute by a three-stage set of steam ejectors. Uncondensed gases are burned and the condensate is routed to the oil catchers.

Short residuum from the bottom of the flash tower is pumped first through the bottoms-to-feed exchangers, then through steam regenerators, and finally either to the asphalt-blowing unit, refinery fuel, or to storage preliminary to being blended into fuel oil.

Catalytic Cracking Unit and Gas Tail

The catalytic cracker of the heat-balanced type has a rated fresh-feed capacity of 1825 metric tons of flashed distillate per stream-day.

Improved Efficiency Design

Although using the fluid bed process, the unit embodies a number of design features for efficient operations, reducing capital outlay and decreasing maintenance costs.

The reactor and regenerator are placed at low elevation with an external stripping vessel located above and supported by the reactor. This arrangement reduces the cost of the structure since the stripper is considerably smaller than the other two vessels. Further, only one riser is needed. This carries spent catalyst from the reactor to the stripper and provides efficient dispersal-phase stripping with steam serving both transport and stripping medium.

The slide valves were designed for low pressure drop. This reduces erosion and allows reduction in the overall height, which is 115 ft.

By using swaged vessels and designing for a relatively high pressure in the reactor (18 psi) and regenerator (20 psi), a larger height: diameter ratio is provided for the dense beds, and low, linear velocities are obtained above the beds. The larger height: diameter bar ratio improves the contacting efficiency between the vapor and catalyst in the dense beds while the low, linear velocities reduce the catalyst loading of the cyclones.

At Bombay, the normal cat-cracker feed is mainly hot product from the feed preparation unit, to which is added the cold feed from storage for temperature control. Upon contact with hot regenerated catalyst, the feed is vaporized. It then enters the reactor. Catalyst to be regenerated is transferred first to the stripper for removal of absorbed and entrained hydrocarbons. The stripped catalyst is then regenerated by burning off the coke. It is the heat from this that

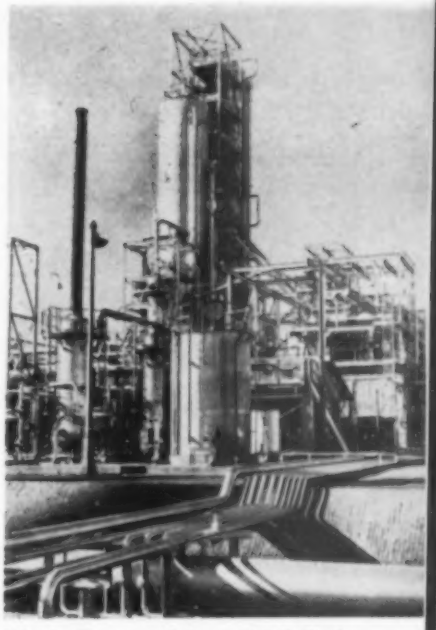

FIG. 3. Close-up of the crude distillation unit showing towers, preheaters, and piping. This unit starts the operation to supply most of India's bitumen (asphalt and road oils).

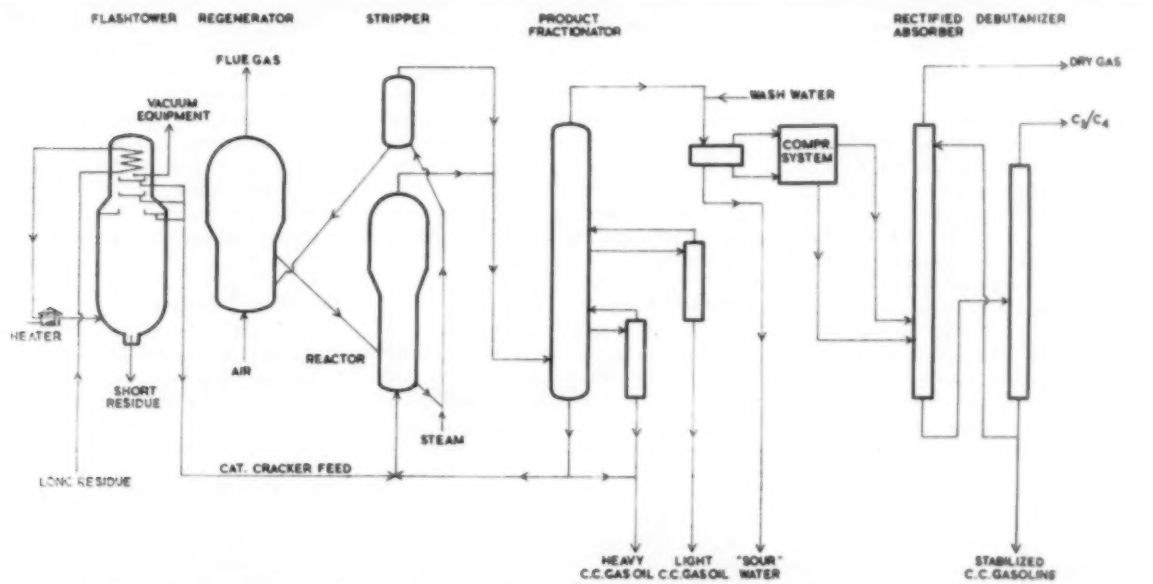

FIG. 4. Simplified flow chart of the combination of vacuum flashing unit, cat cracker, and gas recovery system of the Bombay plant.

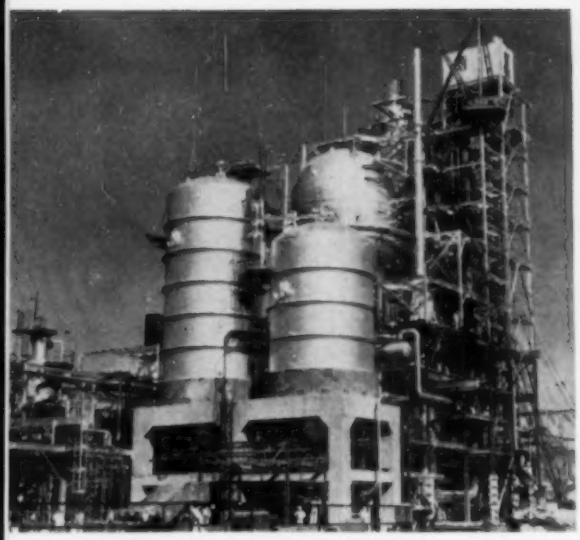

FIG. 5. Fluid cat unit at the Bombay plant, largest refinery in India.

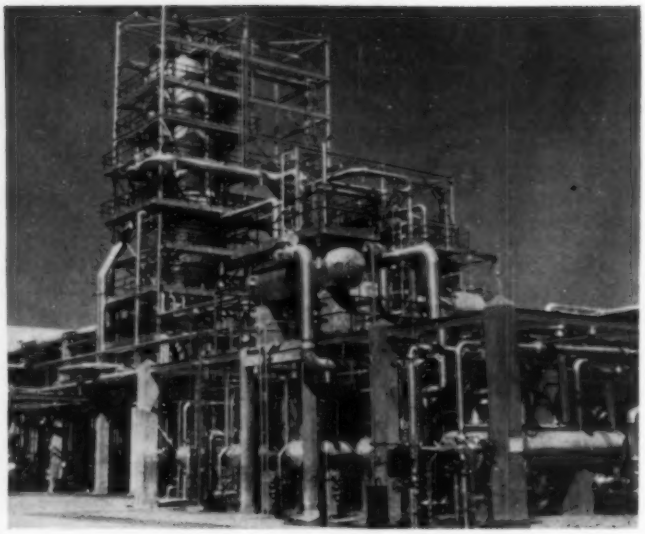

FIG. 6. Cat cracker feed preparation unit, one of the most vital steps in the entire modern refinery.

supplies both the heat of reaction and the latent and sensible heat requirements for the process, including product fractionating. Still in the vapor state, the reaction products leave the reactor and, together with the vapor from the external stripper, pass to the product fractionator.

The small amount of catalyst leaving the reactor and the stripper cyclones with the vapor is concentrated by the fractionator in the slurry oil. Most of this stream is recycled to the reactor after being used as a heat transfer medium.

The balance goes to storage, where the remainder of the catalyst settles out. Light and heavy cat-cracked gas oils are withdrawn as side streams and stripped separately. These products are then transferred to storage pending blending into fuel oil.

Gas and unstabilized gasoline are taken overhead on the fractionator, passed through condensers, and collected in the overhead accumulator. Wash water is injected into the vapor line ahead of the condenser, and this water and condensed steam are withdrawn from the accumulator as "sour water" and transferred to storage before disposal. The hydrocarbon liquid and vapor are transferred to the compression system. Here two-stage reciprocating compressors, gas-driven, take suction on the vapor. To the vapor at the first stage is added the liquid from the fractionating accumulator. Wash water is injected and the entire stream passes through condensers to the second-stage dry drum, where the "sour-water" is drained and transferred to storage. "Sponged" vapor enters the second stage of the compressor, and the equilibrium liquid is discharged from a pump to the gas recovery system.

Vapor from the second stage is also transferred to the gas-recovery system. It is cooled and charged to the rectifying absorber as well as the liquid. This column is reboiled and uses stabilized gasoline as lean absorber oil and light cat-cracked gas oil as lean sponge oil. The "rich" sponge oil is returned to the product fractionator. In the absorber bottom, 98 to 99 per cent of the C4 fraction and up to 95 per cent of the C3 fraction in the feed are recovered. Dry gas from the top of the absorber is burned as refinery fuel and the bottom product is charged to the debutanizer. At present this column is used to stabilize the cat-cracked gasoline, but it can also be used to complete debutanization. Propane-propylene and excess butane-butylene are taken overhead and routed to the refinery gas system. Part of the stabilized cat-cracked gasoline is recycled as lean absorber oil, and the net production is withdrawn for treating.

Asphalt-Blowing Unit

This unit produces several grades of semi-blown asphalt required by the Indian market. Short residuum, the bottom residue from the feed-preparation unit for the cat cracker is normally charged hot. Alternatively, it can be "cold" charged (265 F) from storage.

Hot feed is further heated by exchange with the product and is then pumped to the blowing column. For maximum heat recovery, the blown product is routed first through a steam super-heater, then through the feed exchanger and finally passes through a waste heat boiler.

With cold feed, neither steam superheater nor waste-heat boiler are used. Instead, after the product exchanger, the feed passes through a furnace before entering blowing column. All heat contained in blown product is used to heat cold feed.

At all times, steam is injected into the column top to maintain gas temperature at a lower figure than the reaction temperature and so avoid after burning. Reaction temperature is naturally higher than feed temperature due to heat released by oxidation of the asphalt.

Gases leaving top of blowing column are stepwise cooled. This results in the blown distillate, oily condensate, and non-condensing gases being released in separate streams. Blown distillate is routed to storage, oily condensate to refinery oil catchers, and non-condensable gases, which are, of course, obnoxious, are burned.

Blown asphalt is transferred to storage.

Gasoline Treating

Before being sweetened, the catalytically cracked and straight-run gasolines are scrubbed with caustic soda to remove acidic materials harmful to product quality and satisfactory sweetening process operation. The two-stage counter-current caustic soda treatment used at Bombay removes any H_2S present and part of the lower molecular weight alkyl mercaptans.

After the two mixer-settler stages, the catalytically cracked gasoline is sweetened by the injection of air and inhibitor. Should there be insufficient

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FIG. 7. At night time, Bombay's crude distillation plant.

carry-over of caustic for rapid air-inhibitor sweetening, additional caustic soda can be pumped into the system.

As air-inhibitor sweetening is not applicable to olefin-free fractions, air-solutizer sweetening is used for the straight-run gasoline. It was chosen in preference to either doctor-treating or mercaptan-extraction processes. This mercaptan conversion process has been developed by the Royal Dutch-Shell group and is essentially a modification of the well-known solutizer process for mercaptan removal.

This single-stage treatment of straight-run gasoline with caustic soda removes certain potential contaminants of the solutizer solution. But to avoid sodium contamination, the carry-over of caustic soda must be minimized. To do this, a coalescer is installed ahead of the sweetening equipment and consists of one mixer-settler stage with mixing facilities arranged to provide the correct combination of mixing intensity and contact time. After passing through the settler, a further coalescer completes the removal of the solutizer solution.

Included in the air-solutizer treater are reconcentration facilities for the periodic removal of water from the solutizer solution. This together with the make-up of other constituents maintains the required inventory and optimum composition of the solutizer solution.

Kerosine Acid Treater

The acid treater is equipped with three mixer-settler stages in which kerosine is contacted with sulfuric acid in counter-current flow. These stages are followed by an acid coalescer, one mixer-settler stage for neutralization with caustic soda and a mixer-coalescer for water-washed products.

By maintaining proper conditions during acid treating, a doctor negative product is obtained while substantial desulfurization takes place with comparatively little acid consumption.

Spent caustic and wash water are discharged to the refinery oil catchers via a neutralization pit to which all vessel drains are connected. Acid sludge is routed partly to the waste disposal system and partly to an acid-sludge storage tank.

Waste Disposal

To prevent deleterious and nuisance effects of spent chemicals, a waste disposal plant handles the "sour" water from various water-washing stages in the catalytic cracker, spent caustic soda from the cracked gasoline plant, spent caustic soda from the straight-run gasoline plant, and sulfuric acid sludge from the kerosine plant.

The spent caustic soda from the catalytically cracked gasoline is neutralized batchwise. After dilution with an equal volume of water, the spent caustic is gradually neutralized by a stream of acid sludge from the kerosine treating. The gases are purged by a stream of fuel gas and burned in a waste-products furnace. Neutralization causes the formation of two layers—the oily top layer only is burned and the aqueous bottom layer is transferred to a homogenizing tank.

Into this tank are also drained the "sour" water from the cat cracker and spent caustic soda from treatment of straight-run gasoline. Homogenized tank contents then undergo continuous neutralization with acid sludge from the kerosine treating and subsequent stripping with steam and fuel gas. Neutralized and stripped water, bottom product from the stripper, is discharged to the refinery catchers, and it is part of this water that is used for the batchwise dilution of spent caustic soda from treating catalytically cracked gasoline. The top product from the stripper passes through a condenser for part removal of steam and is then burned in the boiler house or in a waste-products furnace.

Acid sludge not required for neutralization is sold or burned. Sludge burned is first enriched with fuel oil, homogenized, and atomized with steam in a special water-products furnace nozzle.

Utilities

Electrical power is supplied by the Trombay Thermal Power Station. Three boilers at the refinery with a normal capacity of 30 metric tons per hour provide steam at 265 psi and 707 F. Cooling water is taken from the Bombay harbor and pumped to a suction basin. Used on a once-through basis only, it is returned to the harbor at some distance from the intake point.

Tankage is provided for crude, intermediate, and finished products. In addition to the conventional equipment for adding dye, inhibitor, and tetraethyl lead to the finished motor gasoline, facilities are provided for injecting "ICA" as Shell's "TCP" is known outside of the U. S. and Canada.

Before construction could begin, two other engineering jobs had to be completed. One was to move the Bombay Port Trust Railway and the pipe line through which almost all Bombay's white petroleum products were formerly supplied from island-located storage tanks. The other was to reclaim the salt pans that occupied a large part of the site. Only then could actual construction work commence. Further complications were added to the constructors problems when, in 1954, the monsoon seasons set a new record for rainfall recording 170 in. where 70 in. only was considered normal. Even so the refinery was completed in one year less than the scheduled time.

Construction of this and other new refineries in India—the Standard-Vacuum Refinery Company of India, Ltd., which will be adjacent to the Burmah-Shell Refinery on Trombay Island, and that of Caltax (India), Ltd., at Visakhapatnam on the east coast represent a $125,000,000 investment. The greater part of this was provided by overseas investors. ★ ★ ★

New test method that is simple and gives excellent reproducibility

Determining True Vapor Pressures

William J. Tomsic
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Brea, California

THE Reid vapor pressure method is used by the petroleum industry as a standard test for petroleum liquids. The Reid method is an arbitrary test method that has emanated after considerable test work on various vapor pressure methods. Some of these methods were the Beistle-Prather, Bureau of Explosives, Gard, Reid, and Wade-Campbell.[1]

The Reid vapor pressure is often mistakenly used in place of the true vapor pressure. For pure components, Reid and true vapor pressures should be the same, but for petroleum mixtures, true vapor pressure is generally higher. For some crude oils, true vapor pressure is known to be as much as 1000 per cent higher than the Reid.[2] This is due to the vaporization in the Reid bomb of the highly volatile trace components, methane and ethane, which changes the composition of the liquid whose vapor pressure is being measured. As the quantity of the lightest component present in the liquid is increased, the ratio of the Reid to true vapor pressure will tend to approach unity.

True vapor pressures can be calculated from the fractional analysis of the liquid. Present methods of analysis, however, do not indicate with sufficient accuracy the quantity of highly volatile trace components present in some liquids.[2]

The following test method has been developed for directly determining the true vapor pressure of any liquid. The method is based on the visual determination of the bubble point of the liquid at 100 F.

Presented at California Natural Gasoline Association, Los Angeles.

True vapor pressures for natural gasolines are normally calculated from fractional analysis. For some liquids, such as crude oils, fractional analyses of the highly volatile trace components are difficult to obtain with sufficient accuracy. Reid vapor pressures and true vapor pressures of crude oils are known to differ by as much as 1000 per cent. Hence, the Reid vapor pressure cannot be used in place of the true vapor pressure.

A test method has been developed for determining the true vapor pressure of hydrocarbon liquids. Test consists of superimposing an external pressure on the liquid in excess of true vapor pressure. The external pressure is gradually reduced until the bubble point is reached as determined by visual observation. Results are reported as the true vapor pressure in pounds per square inch at 100 F. Test uses readily available equipment and is simple to conduct. Excellent reproducibility has been obtained.

The test method has been checked against vapor pressures calculated from fractional analysis and from known temperatures and pressures in accumulators with excellent results. A few of the potential uses for the true vapor pressure method are discussed.

Apparatus

(1) A 2 by 6-in. transparent plastic cylinder with two top ⅛-in. pipe connections. Details of the cylinder are given in Fig. 1.

(2) A 5-ft length of ¼-in. Saran tubing with a Schrader check unit and adapter.

(3) A 500 to 1000 milliliter steel scrubber cylinder with two top connections; one connection extending to the bottom of the cylinder.

(4) A pressure gage with a range of 30 in. vacuum to 100 psi pressure.

(5) A mercury manometer with a 30-in. range.

(6) A constant temperature bath controlled at 100 F ± 0.2 F.

(7) Source of 100 psi air pressure.

(8) A vacuum pump capable of producing a vacuum of 1 millimeter of mercury.

The apparatus is assembled as shown in Fig. 2. The valves are numbered to simplify the discussion that follows.

Obtaining Sample

Prior to obtaining the sample several boiling stones are placed in the cylinder. The boiling stones are necessary to agitate the sample, thus preventing supercooling during the testing of the sample.

The plastic cylinder is connected to the source of material to be tested using the Schrader check unit. The sample may be taken from any sample cylinder, tank, or line. Care must be taken not to contaminate the sample with air. The cylinder must not be connected to a source of pressure exceeding the working pressure of the plastic cylinder.

Open the tank or line valve and then open valve 5. Partially open valve 7 and purge the cylinder with at least 5 times its volume. Close valves 7 and 5 and the tank or line valve in the above named order. The sample is

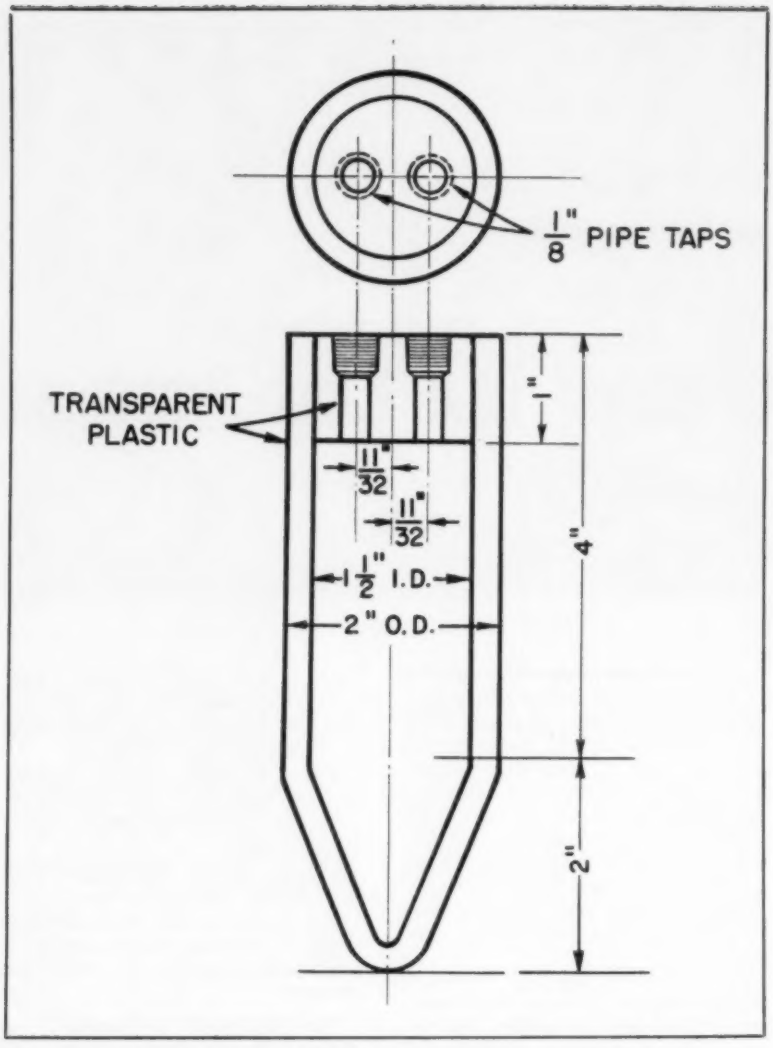

FIG. 1. Cylinder employed in true vapor pressure apparatus.

now ready for testing. Sample must not be allowed to exceed the sampling temperature prior to the testing of the sample.

Determination of Vapor Pressure

Connect the Saran tubing and valve 5 to the steel scrubber using the Schrader check unit and adapter. Open valves 4 and 1. Use valve 3 to pressure the apparatus in excess of the expected vapor pressure. Use the manometer for vapor pressures less than 15 psia. If the vapor pressure is expected to be greater than 15 psia, protect the manometer by closing valve 6 before pressuring with air. Open valve 5 and place the cylinder in the 100 F water bath. The amount of Saran tubing immersed in the water bath is not important.

In setting up the apparatus for measuring very low true vapor pressures, care must be taken to have the cylinder and tubing at the same elevations so that the static head effect is not present.

After 30 minutes have elapsed, crack valve 2, allowing the pressure to reduce gradually. At the same time, continually invert or shake the plastic cylinder under water, allowing the boiling stone to agitate the liquid. Each time the plastic cylinder is inverted, observe the solution for formation of bubbles. When bubbles are noted, close valve 2 and record the indicated pressure on the manometer or pressure gage. If the bubble point pressure was missed by dropping the pressure too rapidly, the apparatus may be repressured. By shaking the cylinder, the bubble will be reabsorbed in the solution. The test can then be repeated.

If the sample has a vapor pressure less than 15 psia, the vacuum pump is used. An increasing vacuum is applied to the scrubber until the bubble point is reached.

As water will boil at about 0.95 psia at 100 F, special precautions are necessary to dehydrate samples containing water. The plastic cylinder is filled with approximately 50 ml of ethylene glycol. The plastic cylinder is then connected to the sample source by neoprene tubing connected to valve 7. A spare Schrader adapter is inserted in the check unit to allow liquid to flow through the Saran tubing. Open valves 7 and 5. Crack valve on sample source and allow material to flow through upright cylinder until the cylinder has been purged with at least 5 times its volume. The glycol will remain in the bottom of the cylinder. Slow the flow to a very low rate and invert the cylinder. Glycol will then flow into the Saran tubing. When the glycol reaches valve 5, shut supply valve and valves 7 and 5. Sufficient glycol will remain in the cylinder to dehydrate the material being tested. The vapor pressure test is conducted in the usual manner.

The results of the test are reported in pounds per square inch of absolute pressure. The manometer readings are converted to pounds per square inch and either added or subtracted from barometric pressure depending on whether a pressure or vacuum reading was obtained. The gage pressure is added to the barometric pressure.

The test method has given excellent reproducibility. The same sample of crude oil has been rerun and the results checked within a few tenths of an inch of mercury.

To verify the results of the test method, samples were run from accumulators whose temperatures and pressures were known. Agreement within one per cent was obtained between the observed and measured vapor pressures. True vapor pressures were also run on samples whose fractional analyses were known. The calculated and measured results checked to within one to two per cent.

Uses of True Vapor Method

The quality of a lean oil influences the absorption of the components in an absorber. Absorber efficiency will decrease as the light ends content of the lean oil is increased. The quality of a lean oil can be determined by the true vapor pressure method.[3,4] The true vapor pressure will indicate the presence of light ends in the lean oil in cases where other control tests will not. In the same manner, the operation of any hydrocarbon stripper or reabsorber can be checked by the true vapor pressure method.

True vapor pressures at different temperatures are needed for process

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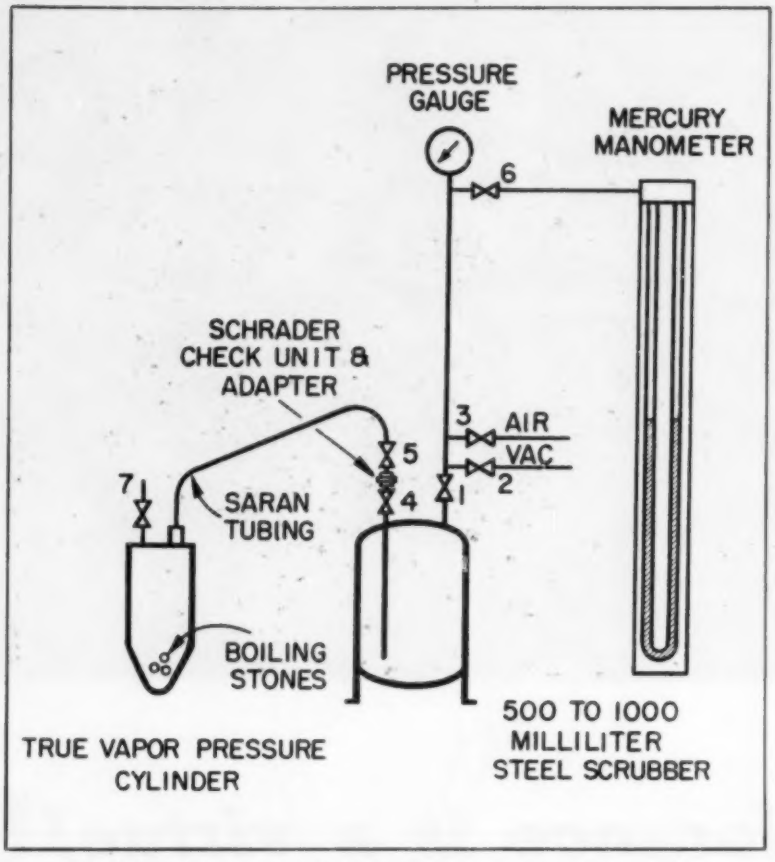

FIG. 2. Flow diagram of entire true vapor pressure apparatus assembly.

design calculations, estimating conditions in accumulators, safety considerations for handling materials, and numerous other uses. The Cox chart is commonly used to determine the change in vapor pressure of hydrocarbons with temperature. The vapor pressure test can be carried out at different temperatures to give a line on the Cox chart. We have found that for some crude oils, the vapor pressure does not increase as rapidly with temperature as predicted by the Cox chart.

Molecular weights can also be approximated by the use of true vapor pressures. It is well known that when two liquids following Raoult's Law are blended together, the resulting true vapor pressure is the sum contributed by each liquid. Each liquid contributes an amount equal to its molecular fraction times its true vapor pressure. A liquid whose molecular weight and true vapor pressure are known can be accurately blended in a second liquid with a known true vapor pressure. The true vapor pressure of the mixture can then be determined. The molecular weight of the other liquid can then be calculated by assuming molecular weights until the observed and calculated true vapor pressures are the same. Or if the molecular weights are known, vapor pressures of the blends of two or more liquids can be calculated if their individual true vapor pressures are known.

Vapor losses from storage tanks are also dependent on the true vapor pressure of the material in the tanks.[5]

Summary

A test method has been developed for the determination of the true vapor pressure of hydrocarbon liquids. The method is simple and gives excellent reproducibility.

Acknowledgment

The test method was developed by Robert A. King of Union Oil Company prior to his death on July 6, 1954. It is hoped that his test method will serve a useful place in the technology of the petroleum industry.

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★ ★ ★

Texas Marks 58 Years of Refinery Growth

From the couple of tubs and the pine tree kindling that was Texas' first oil processing plant, Texas' petroleum refining industry in 67 years has grown into a $2.5 billion manufacturing enterprise.

Texas' 58 operating refineries make up one of the state's major industries, highly competitive, with the key to survival being constant improvement to meet demands of the American consumer, according to the Texas Mid-Continent Oil & Gas Association.

The first oil processing plant in Texas (which operated at Oil Springs, Nacogdoches, in 1888) was little more than a grease plant, boiling off the lighter fluids from the crude oil and using only the heavier lubricants.

The first real Texas oil refinery operated at Sour Lake in 1896, turning out eight different grades of oil. The next refinery at Sour Lake, built two years later, was sold in 1899 for $6385.

In 1898 a $150,000 refinery was built at Corsicana, representing a major step toward marketing finished products of Texas crude oil.

Spindletop was discovered in 1901 and the demand for oil products began to rise. Three refineries were constructed in the Beaumont-Port Arthur district to process Spindletop crude.

In 1912 there were 11 refineries in Texas with total crude capacity of 10,000 bbl daily. West Texas got its first refinery in 1919 and in 1920 a refinery was built at Oil Springs to process the revived area's oil.

Refinery growth was steady and by 1930 Texas refineries were processing over 215,000,000 bbl a year, accounting for 74 per cent of the state's crude production.

Discovery of the East Texas field set off a splurge of refinery building, although the major portion of the field's 80 refineries in 1933 were little more than skimming plants.

Last year, 703,732,000 bbl of crude oil, or 71.7 per cent of the state's production, was processed in Texas. This represents a steady increase in the amount of Texas output refined in the state since 1950, when 67 per cent was processed.

The state's refineries at present have a crude oil capacity of 2,300,000 bbl a day, representing 27 per cent of the nation's refining capacity. Largest of these plants has a capacity of over 300,000 bbl a day, another more than 270,000 bbl, and two others have capacities of 200,000 bbl or more.

Refineries spend millions in modernizing their facilities. One plant last year spent $10,000,000 on one unit.

Petrochemicals Unlimited: From Ethane, Propane, Butanes

Oxygenated Petrochemicals

Peter W. Sherwood
Chemical Engineer

Part IV, Section 2: Ethyl and propyl alcohol, ethylene, styrene oxide

Commercial practice followed in the liquid-phase synthesis of monohydric alcohols is best considered in relation to the specific production of ethanol and isopropanol, the most important members of the series.

Liquid-Phase Synthesis of Ethyl Alcohol. Five major factors have made the liquid-phase hydration economical for ethanol production:

(a) The ease with which higher olefins may be removed from ethylene by absorption in 85 per cent sulfuric acid.

(b) The discovery that absorption of ethylene in sulfuric acid is greatly expedited by the presence of ethyl sulfuric acid.

(c) The discovery of conditions that permit formation of diethyl sulfate in large concentration, thereby reducing acid consumption.

(d) The finding that high pressure results in substantial increase in absorption equilibrium and rate, and

(e) The favorable effect of alcohol elimination from the absorption medium.

Using pure ethylene and 66 deg Bé H_2SO_4, Strahler and Hachtel[7] found that diethyl sulfate formation at equilibrium rises rapidly between 180 and 225 psi system pressure. Above 225 psi, diethylene sulfate content maintains an assymptotic value of 25 per cent (based on absorbed ethylene). Within this range, polymerization of ethylene is insignificantly affected by pressure, so that ethylene partial pressure of 225 psi may be considered an optimum value, at least insofar as equilibrium considerations are concerned. However kinetic studies by Brooks[8] show that absorption rate continues to rise as pressure is raised to 500 psi and possibly above.

At 225 psi and 66 deg Bé sulfuric acid, ethylene absorption rises markedly with temperature until it reaches an assymptotic value (approximate 120 per cent of theoretical ethyl sulfuric acid) at 65 to 70 C.

Ethylene absorption is very markedly influenced by acid concentration. Thus, Brooks[8] was able to absorb 1.56 moles ethylene per mole H_2SO_4 at 97.5 per cent strength (50 C, 45 deg psi). In 95 per cent H_2SO_4, absorption stopped after 1.28 moles ethylene had been introduced. At the same time, absorption rate was significantly boosted by acid strength.

Various catalysts have been proposed to expedite the esterification process. Limited value is found in their use (*e.g.*, 10 per cent Ag_2SO_4), but they have not been reported in industrial application. Such catalysts do not affect the total amount of ethylene absorbed at equilibrium, but they do influence the per cent diethyl sulfate formation.

Hydrolysis is effected by water dilution (to approximately 50 per cent) and at the boiling point of the system. Ammonia is on occasion used as hydrolysis aid (which will lead to the formation of by-product ammonium sulfate). More commonly, such aids are avoided and spent sulfuric acid is re-concentrated.

Crude alcohol is taken overhead as it is formed. It is accompanied by about 5 per cent ether, a product primarily of diethyl sulfate hydrolysis, and an important saleable by-product of the alcohol process. The overhead vapors are caustic-scrubbed for elimination of contained acids. They are then condensed and taken to crude alcohol storage ready for distillative purification of product alcohol and ether. Overall yield of alcohol is 85 to 88 per cent based on absorbed ethylene. Industry-wide, average yield of 95 per cent ethyl alcohol is reported to be 0.23 gal per pound ethylene gas (86 per cent of theory) and 0.65 gal/gal ethyl sulfate.

Liquid-Phase Synthesis of Isopropyl Alcohol. For esterification of propylene, the optimum sulfuric acid concentration is between 75 and 85 per cent. Ideally, the monohydrate of sulfuric acid (84 per cent) would be most desirable, since operation at this concentration would cause no build-up of free water with its concomitant adverse effect on absorption rate as the reaction progresses. Actually, side reactions that occur to a significant extent modify this picture and provide the reason for selection of lower acid concentrations.

Foremost among these secondary reactions is the formation of diisopropyl sulfate. This intermediate is itself susceptible to conversion to isopropanol upon hydrolysis, and while its occurrence reduces over-all acid consumption, it also leads to the production of diisopropyl ether in significant amounts. Unless markets for this by-product are assured in adequate volume, its formation must therefore, be suppressed by operating with more dilute acid. It has been shown[9] that diisopropyl sulfate cannot be formed in the presence of any appreciable amount of free water.

The main reaction system is controlled by the equilibrium between propylene, isopropyl sulfate and isopropanol. Even in acid of 80 per cent strength, only about 35 per cent of the

EXCLUSIVE

absorbed propylene will be present as the sulfate[10] if an acid: hydrocarbon ratio of 1 is used. The percentage of propylene present as sulfate drops sharply as the acid is diluted and is only about 4 per cent at 45 per cent acid strength. This shift in equilibrium is, of course, the basis of the commercial two-step process.

According to Schrage and Amick,[10] conversion of propylene to isopropyl alcohol is surprisingly independent of hydrocarbon:acid ratio. Formation of isopropyl ether, however, passes through a maximum value at mole ratios of 0.6 to 0.8, with consequent drop in propylene efficiency.

Use of elevated pressure raises the absorption rate and thus permits operation at lower temperatures and acid concentration than would otherwise be feasible.[11] Prime advantages of this mode of operation are the repression of polymerization reactions and of sulfone formation, and avoidance of alcohol dehydration (*i.e.*, reversion to propylene). Furthermore, use of pressure permits operation entirely in the liquid phase.

An operating pressure of 300 psi is reported for the absorption unit at Rheinpreussen, which serves for the first step in the production of isopropanol and s-butanol from a propene-butene mixture.[12] At this plant, incidentally, the sulfation reaction is, or has been, carried out in batch autoclaves. Most other plants operate on a continuous basis.

Here, the hydrocarbon feed is a C_3-C_4 fraction containing approximately 10 per cent propene and 27 per cent butene-2 (almost no isobutylene). This mixture is compressed and liquefied and is then contacted with 75 per cent sulfuric acid in agitated autoclaves. The reaction is started at room temperature but is allowed to rise to 60 C.

Contact time is about 1 hr. At the conclusion of this period, substantially all the propylene has been absorbed while some 8 per cent of the butylene remains unconverted in the hydrocarbon phase. Polymerization of butene accounts for nearly 22 per cent of this olefin. Propylene is, of course, much less prone to polymerization, and losses due to this side reaction are not serious. At the conclusion of the esterification reaction, the charge is removed from the autoclave and residual hydrocarbon is separated from the acid layer.

Hydrolysis of Isopropyl Sulfate. The extent of dilution required for full hydrolysis increases with the molecular weight of the alcohol. At the Rheinpreussen plant, where s-butanol is produced together with isopropanol, enough water is added to reduce acid concentration to 25 per cent (for isopropanol production alone, final concentration of 30 to 40 per cent would be adequate).

In the first dilution step, acid strength is taken to 30 per cent. The diluted acid phase is fed continuously to a cascade of four carbon-lined hydrolizers, each provided with an internal baffle. Live steam is admitted to each hydrolizer, and evolved vapors are collected in an overhead main connecting the four units.

Reaction temperature in successive hydrolizers is 80, 95 and 100 C, respectively. The last vessel, in which an acid concentration of about 25 per cent prevails, is operated at the boiling point of its contents. Effluent acid is substantially free of alcohols or esters and may be taken directly to the reconcentration stage.

The overhead from the hydrolizers is cooled for condensation of the alcohols. No propylene is found in the gas phase. Some butene, however, is formed at the acid concentration provided. For its complete elimination, final acid content would have to be taken to uneconomically low values.

The condensate consists primarily of the desired alcohols and water plus about 5 per cent ether (based on alco-

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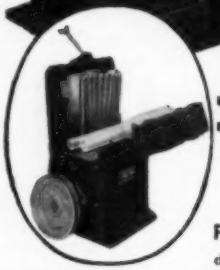

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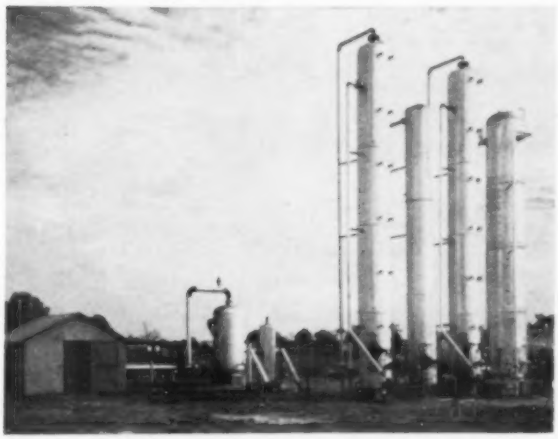

Typical absorber battery, well spaced, showing scrubbers and metering station.

These three areas would be separated and isolated in the ideal natural gasoline plant.

Operating Area

Absorbers. The interest of safety and utility is best served when absorbers are located on the down flank of an elevated ridge when the boilers, fired heaters, and compressors can be placed on the other. Likewise, absorbers are often installed as a battery of two or more with a high degree of safety. It is logical to fix 150 ft as a minimum distance between absorbers and any continuous exposed flame, based on the opinion of all plant operators consulted. A greater distance would not insure complete safety, but a shorter distance is certainly considered dangerous.

In view of the fact that scrubbers and separators are an adjacent and integral part of the absorber unit, they would abide by the same rule.

Stills, Fractionators, Etc.

The distillation and fractionation units of a plant provide the area in which much of the flammable material of the plant is present. With possibly the exception of the storage area, the bulk of the liquid fuel and vapors are continuously present in this area. These units may be well located in low spots in the plant, so that any break or leak will not drain toward a source of ignition such as a boiler, direct-fired heater, or compressor building. Stills and their contents are not as volatile as fractionators and therefore should be 100 ft or more from any continuous exposed flame. The vapor content and higher pressure of fractionators demand that they be 200 ft for an open flame.

Pump Houses

Pump houses handling flammable liquids present much the same hazard as the distillation area. Usually the pumps are an integral part of the distillation and fractionation units. They lack the storage content of vessels and tanks and can usually be shut off in case of break or leak, although their contents are often identical or equally as volatile and flammable as the process unit material. They present a hazard equal to any continuous exposed flame and should therefore warrant the minimum spacing of 200 ft from such a source of ignition.

Treating and Blending

These operations are not present in all natural gasoline plants. In some plants acid treating may be present and continuous. In others lead blending may be in operation only part time. These operations present a liquid and vapor fuel hazard to a large degree. Lead suppliers often specify the spacing distances for this operation and their distances should be the rule. Their greatest exposure is an open flame and treating operations should be 150 ft away, while blending of volatile liquids should be at least 200 ft from any continuous exposed fire.

Cooling Towers

The belief that a cooling tower is not subject to fire is highly erroneous. Many water cooling towers have been completely destroyed by fire. This is explained by the fact that plant cooling water is often contaminated by gasoline and oils from leaks in coolers and condensers. This highly flammable material saturates the tower structure and accumulates on the surface of the water in the basin where the smallest spark or flame may ignite it.

Cooling towers should be located on the highest crest in the plant, but not nearer than 100 ft to any continuous exposed flame. Mist and water vapor from towers has a very costly corrosion and rust effect on immediately adjacent metal equipment and should never be so located.

It is generally agreed that both forced draft and atmospheric type towers fall in the same category where considered for spacing.

Ignition Area

Compressors. Compressors, powered by gas engines, should not be located in low spots with reference to the rest of the plant. They are best located near the crest of a ridge or on a rise in elevation. An ideal location would be the boiler plant, compressor room, and cooling tower on the crest of separate ridges. Compressors are a secondary source of ignition as well as an area where flammable vapors may be intermittently or continuously present. They present a potential explosion hazard and therefore warrant the minimum 100 ft of spacing from the process area of the plant.

Auxiliaries—Air, Electricity, etc. The plant utilities, such as the electrical generator room, air compressor, etc., are key points in a plant and should be kept at safe distance from the process area. Damage to the electrical source or circuit to or within a plant can shut it down. Such auxiliary installations should be 100 ft or more from the process area. A general and safe spacing practice is to locate these units in the same general area as the compressors.

It is highly desirable to keep all electric power lines and poles as remote as possible from the process area. Circuits handling 220 volts or more are especially hazardous within 50 ft or less. Electric wires provide not only a source of ignition but, if broken or fallen, may energize all metal parts of the plant exposing personnel to shock and electrocution.

Boilers and Direct Fire Heaters. Boilers and direct-fired heaters are the primary ignition source in any plant as

A well-spaced arrangement of a direct-fired heater and boiler house; boiler feed pump house is at extreme left, boilers in center, heater at right.

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they provide a continuous exposed flame. They should be on the windward side of the plant, not less than 100 ft from any other operating unit, and on the opposite side of the plant from the storage area by at least 100 ft. Fire stills, and direct-fired heaters may, however, be placed near boilers as a safety precaution as well as a convenience. Boilers and heaters should never be located at low spots with reference to the rest of the plant.

Flares. The day of the large plant flare has passed due largely to the rules of conservation. There are, however, some undesirable and waste gases present in many plants that must be consumed. Such flares should receive maximum isolation whenever possible and be at least 200 ft away from areas where vapor and liquids are constantly present. No flare should be closer than 100 ft to any operating unit of the plant regardless of its make-up. The plant flare should receive the greatest spacing possible, when it is used for plant blow-down or emergency relief. In such case, it should be considerably more than the distances given in the table up to 500 ft or more, where large quantities of gas or liquid are involved.

Loading Racks. Most gasoline plants have either a tank truck or a tank car loading rack while many others have both. The hazards in each case are almost identical, however, the extent and degree of exposure is different. In tank truck loading, each truck that enters to load or unload brings a potential source of ignition from either engine exhaust, electrical systems, or static. Sometimes hundreds of trucks visit a loading rack daily. The railroad or tank car rack is not visited as ofter by steam engines, locomotives, or diesels and consequently does not have an equal exposure.

The Association of American Railroads has set up definite spacing relative to loading racks and railroads. Briefly, racks that load up to 16 lb vapor pressure products must be 50 ft from the tracks and racks loading products over 16 lb vapor pressure must be 100 ft from the tracks.

Loading racks have the inherent hazard of flammable vapors and should be at least 200 ft from any continuous exposed flame.

Office and Buildings. In general, buildings housing personnel such as an office, warehouse, or laboratory should be placed reasonably close to the plant entrance, but outside the operation danger zone and on the side opposite the plant storage. Likewise they should be so located that it will not be necessary for personnel to walk or drive through the process or storage area to reach them. The inherent danger of smoking and motor car exhaust is ever present.

Offices and laboratories usually have open flames and provide a source of ignition for vapors or gases released in the plant and therefore should be at least 100 ft from the operating area.

Storage Area

The storage area presents a complex problem in spacing. Often local, county, state, or federal regulations list specific distances. Certain insurance and industrial codes also define distances. The Association of American Railroads also sets certain distances. The spacing shown on Table 2 complies with all rules and regulations generally in effect to the best of the author's knowledge. It is entirely possible that other codes or rules with conflicting distances govern specific locations and areas. This should be determined before laying out a plant storage area.

Firewalls and Fire Lanes. Fire walls or dikes are considered necessary around practically all tanks. Their main function is to hold any overflow, leakage, or spillage, but they also protect tanks from the spread of burning liquids and flood waters. The API and NBFU codes specify the details of firewall construction, but generally they must be

Location of this storage area isolates it from the main plant, by the cooling tower placed between, is another example of proper arrangement and spacing.

3 ft or higher and so located to retain the contents of the tank.

High firewalls have been found to be a serious disadvantage in fire fighting, stopping leaks, and even ordinary maintenance.

Recently plant operators have found the diking of butane-propane storage areas a valuable protection against spread of burning liquids, encroachment of flood waters, as well as accidental entry or collision by vehicles. Where aggregate storage is 5000 bbl or morein a single plot, the entire group is usually enclosed by dike so that there will be a great diffusion into the air of any spillage or break and thus reduce the hazard.

Most plants are subject to encroachment of fire from outside sources. This is especially true of isolated rural plants in wooded areas where forest and grass fires occur. A standard practice is the cutting of a fire lane around the plant proper. Turning plows and discs are often used twice a year or more to retard growth of vegetation. Weed and vegetation killers are also used in many localities where growth is prolific. These fire lanes should never be less than 20 ft in width. Where trees and shrubbery are present the width should be materially increased to prevent flames leaping the firebreak.

Conclusion

Radical changes in natural gasoline plant layout and spacing have been made during the past ten years. Newer materials and processes as well as better and more effective fire extinguishing agents and methods have been developed.

When these advantages are combined in the modern day plant erection, the economy of first cost and maintenance as well as safety and convenience are automatically present. The trend today should be to plan the plant for safety first and the other advantages will follow. Engineers and designers will do well to consult a qualified fire protection or safety engineer while their plants are in the planning or blueprint stage to prevent building a death trap for humans and a catastrophe for stockholders.

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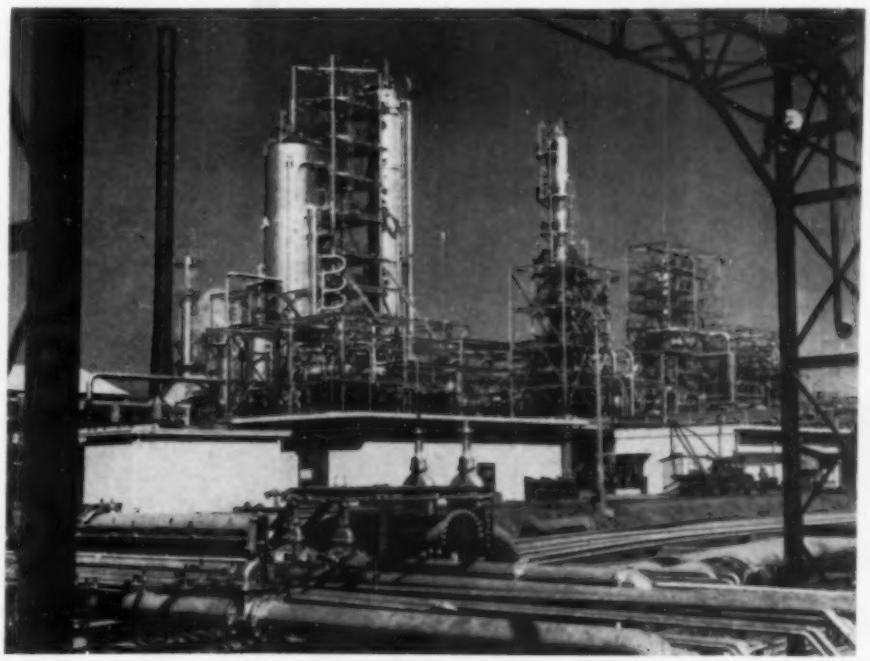

FIG. 1. "Heart" of the Bombay refinery—crude distillation unit, which handles nearly 44,000 bbl per day of tanker-transported crude. At right, cat cracker feed preparation unit.

Largest Indian Refinery on Stream

Burmah Oil-Anglo-Saxon's Bombay refinery cost $64,000,000; to process 14,600,000 bbl per yr; shows new highs in operating efficiency

C. Morgan Jones
European Correspondent

INDIA'S largest oil refinery with an annual capacity of 14,600,000 bbl of crude (2,000,000 metric tons) is in full operation. Located at Trombay Island in the Bombay harbor area, its total construction costs exceeded $64,000,000.

Built by Burmah-Shell Refineries, Ltd. (Burmah-Oil Company, Ltd.), and the Anglo-Saxon Petroleum Company, Ltd. (a Royal Dutch-Shell group company), products from the refinery will be marketed by the Burmah-Shell Oil Storage and Distributing Company of India, Ltd., which is also jointly owned by Burmah-Oil Company and the Anglo-Saxon Petroleum Company.

General Refinery Flow

Crude oil for the refinery arrives in tankers that unload at the newly constructed Butcher Island Marine Terminal. Crude is then pumped through underwater pipe lines to the tank farm.

From the farm, the crude is charged to the distilling unit, which produces both intermediate and finished products. The straight-run gasoline and kerosine are finished by chemical treatments; light and heavy gas oils are used for the middle distillates; while the long residue is charged to the vacuum flashing unit, which provides the charging stock for the catalytic cracking unit.

In addition to cat-cracker feed, the vacuum flasher unit produces short residuum part of which is passed to an asphalt-blowing plant. The balance is used either as refinery fuel or as a fuel oil component.

The waxy distillate fed to the catalytic cracking unit is converted into gas, cat-cracked gasoline, light and heavy catalytic gas oils, and coke. Coke formed is consumed in the process. Gas and gasoline then pass through the compression system to the fractionating columns of the gas-recovery section. Part of the gas is used as a refinery fuel while the gasoline is charged

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Although the M.W. Kellogg, Sinclair-Baker process is still too new in service to provide any long-term performance data, and customers' initial findings cannot yet be disclosed, many economic advantages of this catalytic naphtha reforming process have already been firmly established. Any refiner faced with increasing octane yields from present feedstocks, or with getting high octane reformates from lower grade naphthas, will recognize the significance of the following points . . .

Quick Start-Up

Experimental operation is reduced to a minimum. One M. W. Kellogg reforming unit was started on its final test run within two weeks after the catalyst was first charged to the reactors—with octane rating and yield during this 15-day period well in excess of the guarantee.

A Regenerative Catalyst

Sinclair-Baker Platinum Catalyst RD-150 can be regenerated easily and quickly *in situ* to provide many operating cycles, each of many months duration, with negligible loss in catalyst activity. Cost of catalyst per pound in terms of barrels of reformate produced is a major economic factor of the process.

Long Catalyst Life

Sinclair-Baker regenerative catalyst RD-150 has high activity and long initial life. It has been in operation for over one year without supplementing the catalyst. 95 octane reformate can be produced for six months or longer before regeneration is required.

Octane Level

Depending on the feedstock, clear octane ratings above 90 are now being obtained commercially—with 100, and even better, a goal that is entirely feasible and economically practical. *Variability* of octane rating is the keynote of the process, permitting selection of the exact processing conditions for a given naphtha to secure optimum economic operation at all times.

Supply of Catalyst

Use of the process does not obligate refiners to buy Catalyst RD-150 beyond the first year's requirements, although a continuing source of supply can be assured. This freedom from long-term purchase and license agreements is an important consideration when deciding which is the most suitable reforming process.

Low Grade Naphtha Feeds

M. W. Kellogg's unique design permits the effective desulphurization of low grade naphthas as part of the process, and avoids corrosion and metal contamination. Kuwait naphthas thus treated, for example, can produce yields of high octane reformates only slightly lower than those for higher grade Mid-Continent feedstocks.

For More Information

Further details on M. W. Kellogg's catalytic naphtha reforming process, the Sinclair-Baker catalyst, together with some economics of both, are contained in a recent booklet, "Low Cost Production of 95 Octane Clear Reformate." Copy sent on request.

Refinery Process Division

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to treating facilities. The light and heavy catalytic gas oils recovered from the cat-cracker product fractionator are blended into fuel oil.

Finished motor gasoline is prepared by first caustic scrubbing and sweetening the straight-run and cat-cracked components and then adding inhibitor, dye, and tetraethyl lead to the actual blends. The kerosine fraction from the crude distilling unit is acid treated to bring it up to marketing specifications.

Both white products and black oils are transferred by pipe line to two nearby terminals. Sewri, four miles away, handles automotive gas oil (diesel), kerosine, and gasoline. Wadi Bunder, a further three miles away, is restricted to handling black oils. Products are delivered from refinery by railroad tank cars.

Crude Oil Distilling Unit

The distilling unit is designed for an intake of 6000 metric tons (43,800 B/D) of Kuwait crude oil per stream-day. It consists of primary and secondary column, a stabilizer, and three strippers.

Crude oil is pumped from storage through several heat exchangers, partly vaporized in a furnace, and then charged to the primary column. Unstabilized gasoline is taken overhead, condensed, and fed to a stabilizer. This column produces 9-lb RVP gasoline as a bottom product, and the light hydrocarbons comprising the top product are routed to the refinery gas system.

Stabilized straight-run gasoline is caustic treated prior to being sweetened. Light kerosine is withdrawn as a side stream from the primary column and is stripped in the kerosine stripper.

The primary-column bottom product is further heated and then charged to the secondary column, which operates at 300 mm Hg absolute. In addition, stripping steam is injected. The overhead vapors pass to the vacuum system and are condensed, the water being drained and the hydrocarbon phase transferred to the kerosine stripper of the primary column.

Heavy kerosine is withdrawn directly as a side stream from the secondary column. Light and heavy gas oils are similarly withdrawn and are separately stripped. Light and heavy kerosine streams are run together to intermediate storage prior to being charged to the kerosine acid treater.

The light and heavy gas oils are cooled and sent to storage before being blended into middle distillates for sales. The long residue from the bottom of the secondary column after heat exchange with the crude oil is either fed hot to the vacuum flashing unit or is cooled and transferred to storage.

Cat-Cracker Feed Preparation

Vacuum flashing is used for the preparation of the cat-cracker feed stock from the long residuum.

The unit is essentially the same in design as those used in some of the European refineries of the Royal Dutch-Shell group.

Normally, long residue is charged hot from the crude oil distilling unit. The feed pumps of the feed preparation unit circulate the charge through internal vapor-to-feed exchangers, then through bottoms-to-feed exchangers, and finally through a heater and into the bottom of the flash tower. Here the pressure is 40 to 60 mm Hg absolute. The resultant flash vaporization produces the primary separation between the distillate and short residuum.

The vaporized distillate passes upward through demisters, which reduce the entrainment of the asphaltenes and metal contaminants in the cat-cracker feed. The residual material removed by the demisters is recycled to the feed line but part is cooled and recycled to the entrainment-removal plate, where

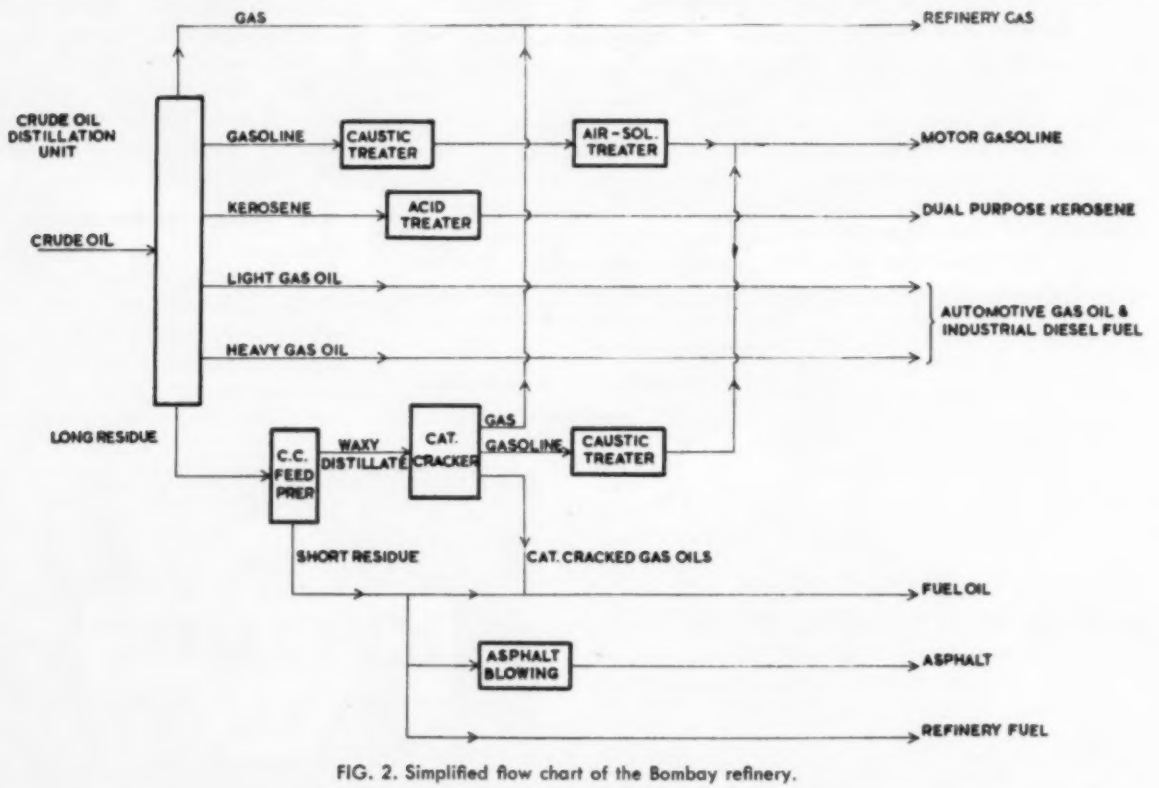

FIG. 2. Simplified flow chart of the Bombay refinery.

its washing action minimizes coke deposition.

Vapor leaving the demisters continues upward, past a top deck, through the flash tower, and then downward over the external vapor-to-feed accumulator.

This vessel also receives the liquid that condenses on both the tower walls above the top deck and the shell enclosing the internal exchangers and condensers.

Uncondensed vapor from the flash tower is sent to a condensing tower, where part of the vapor is condensed by contact with cooled condensate refluxed through the tower. This material is injected into the distillate from the accumulator and the combined stream either goes through hot to the cat cracker or is cooled before being transferred to storage.

From the top of the condensing tower, the remaining uncondensed vapor is withdrawn at 20 mm Hg absolute by a three-stage set of steam ejectors. Uncondensed gases are burned and the condensate is routed to the oil catchers.

Short residuum from the bottom of the flash tower is pumped first through the bottoms-to-feed exchangers, then through steam regenerators, and finally either to the asphalt-blowing unit, refinery fuel, or to storage preliminary to being blended into fuel oil.

Catalytic Cracking Unit and Gas Tail

The catalytic cracker of the heat-balanced type has a rated fresh-feed capacity of 1825 metric tons of flashed distillate per stream-day.

Improved Efficiency Design

Although using the fluid bed process, the unit embodies a number of design features for efficient operations, reducing capital outlay and decreasing maintenance costs.

The reactor and regenerator are placed at low elevation with an external stripping vessel located above and supported by the reactor. This arrangement reduces the cost of the structure since the stripper is considerably smaller than the other two vessels. Further, only one riser is needed. This carries spent catalyst from the reactor to the stripper and provides efficient dispersal-phase stripping with steam serving both transport and stripping medium.

The slide valves were designed for low pressure drop. This reduces erosion and allows reduction in the overall height, which is 115 ft.

By using swaged vessels and designing for a relatively high pressure in the reactor (18 psi) and regenerator (20 psi), a larger height: diameter ratio is provided for the dense beds, and low, linear velocities are obtained above the beds. The larger height: diameter bar ratio improves the contacting efficiency between the vapor and catalyst in the dense beds while the low, linear velocities reduce the catalyst loading of the cyclones.

At Bombay, the normal cat-cracker feed is mainly hot product from the feed preparation unit, to which is added the cold feed from storage for temperature control. Upon contact with hot regenerated catalyst, the feed is vaporized. It then enters the reactor. Catalyst to be regenerated is transferred first to the stripper for removal of absorbed and entrained hydrocarbons. The stripped catalyst is then regenerated by burning off the coke. It is the heat from this that

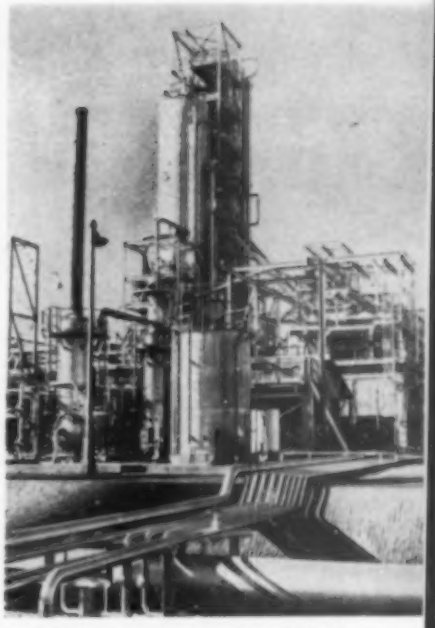

FIG. 3. Close-up of the crude distillation unit showing towers, preheaters, and piping. This unit starts the operation to supply most of India's bitumen (asphalt and road oils).

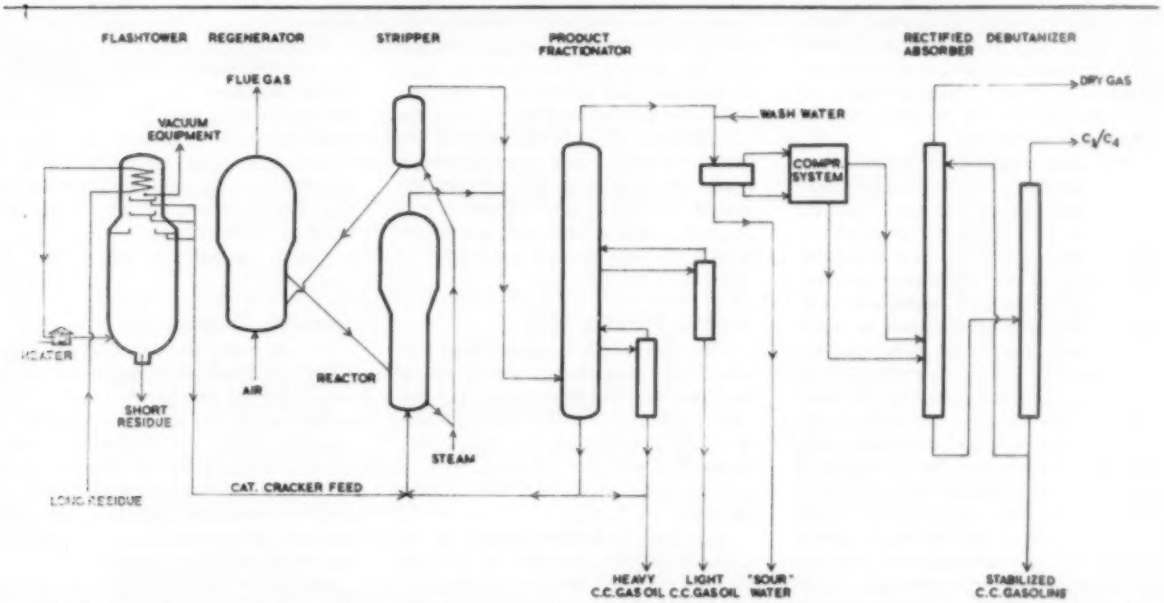

FIG. 4. Simplified flow chart of the combination of vacuum flashing unit, cat cracker, and gas recovery system of the Bombay plant.

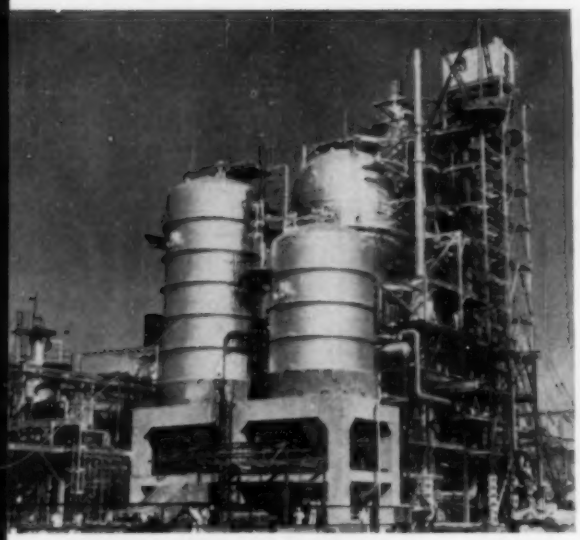

FIG. 5. Fluid cat unit at the Bombay plant, largest refinery in India.

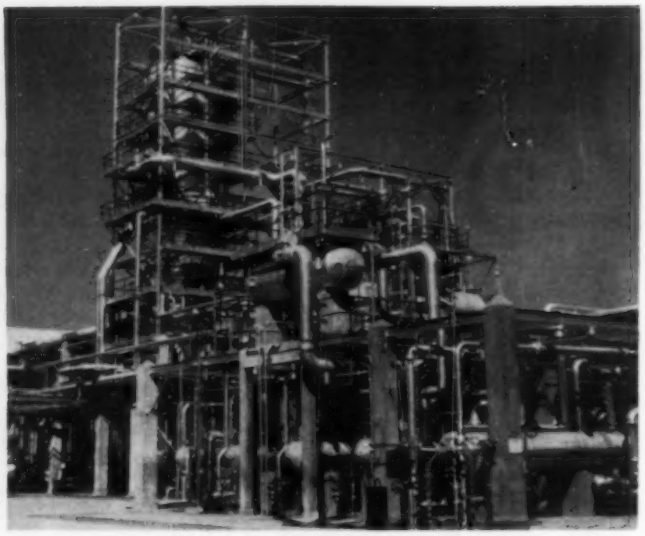

FIG. 6. Cat cracker feed preparation unit, one of the most vital steps in the entire modern refinery.

supplies both the heat of reaction and the latent and sensible heat requirements for the process, including product fractionating. Still in the vapor state, the reaction products leave the reactor and, together with the vapor from the external stripper, pass to the product fractionator.

The small amount of catalyst leaving the reactor and the stripper cyclones with the vapor is concentrated by the fractionator in the slurry oil. Most of this stream is recycled to the reactor after being used as a heat transfer medium.

The balance goes to storage, where the remainder of the catalyst settles out. Light and heavy cat-cracked gas oils are withdrawn as side streams and stripped separately. These products are then transferred to storage pending blending into fuel oil.

Gas and unstabilized gasoline are taken overhead on the fractionator, passed through condensers, and collected in the overhead accumulator. Wash water is injected into the vapor line ahead of the condenser, and this water and condensed steam are withdrawn from the accumulator as "sour water" and transferred to storage before disposal. The hydrocarbon liquid and vapor are transferred to the compression system. Here two-stage reciprocating compressors, gas-driven, take suction on the vapor. To the vapor at the first stage is added the liquid from the fractionating accumulator. Wash water is injected and the entire stream passes through condensers to the second-stage dry drum, where the "sour-water" is drained and transferred to storage. "Sponged" vapor enters the second stage of the compressor, and the equilibrium liquid is discharged from a pump to the gas recovery system.

Vapor from the second stage is also transferred to the gas-recovery system. It is cooled and charged to the rectifying absorber as well as the liquid. This column is reboiled and uses stabilized gasoline as lean absorber oil and light cat-cracked gas oil as lean sponge oil. The "rich" sponge oil is returned to the product fractionator. In the absorber bottom, 98 to 99 per cent of the C4 fraction and up to 95 per cent of the C3 fraction in the feed are recovered. Dry gas from the top of the absorber is burned as refinery fuel and the bottom product is charged to the debutanizer. At present this column is used to stabilize the cat-cracked gasoline, but it can also be used to complete debutanization. Propane-propylene and excess butane-butylene are taken overhead and routed to the refinery gas system. Part of the stabilized cat-cracked gasoline is recycled as lean absorber oil, and the net production is withdrawn for treating.

Asphalt-Blowing Unit

This unit produces several grades of semi-blown asphalt required by the Indian market. Short residuum, the bottom residue from the feed-preparation unit for the cat cracker is normally charged hot. Alternatively, it can be "cold" charged (265 F) from storage.

Hot feed is further heated by exchange with the product and is then pumped to the blowing column. For maximum heat recovery, the blown product is routed first through a steam super-heater, then through the feed exchanger and finally passes through a waste heat boiler.

With cold feed, neither steam superheater nor waste-heat boiler are used. Instead, after the product exchanger, the feed passes through a furnace before entering blowing column. All heat contained in blown product is used to heat cold feed.

At all times, steam is injected into the column top to maintain gas temperature at a lower figure than the reaction temperature and so avoid after burning. Reaction temperature is naturally higher than feed temperature due to heat released by oxidation of the asphalt.

Gases leaving top of blowing column are stepwise cooled. This results in the blown distillate, oily condensate, and non-condensing gases being released in separate streams. Blown distillate is routed to storage, oily condensate to refinery oil catchers, and non-condensable gases, which are, of course, obnoxious, are burned.

Blown asphalt is transferred to storage.

Gasoline Treating

Before being sweetened, the catalytically cracked and straight-run gasolines are scrubbed with caustic soda to remove acidic materials harmful to product quality and satisfactory sweetening process operation. The two-stage counter-current caustic soda treatment used at Bombay removes any H_2S present and part of the lower molecular weight alkyl mercaptans.

After the two mixer-settler stages, the catalytically cracked gasoline is sweetened by the injection of air and inhibitor. Should there be insufficient

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FIG. 7. At night time, Bombay's crude distillation plant.

carry-over of caustic for rapid air-inhibitor sweetening, additional caustic soda can be pumped into the system.

As air-inhibitor sweetening is not applicable to olefin-free fractions, air-solutizer sweetening is used for the straight-run gasoline. It was chosen in preference to either doctor-treating or mercaptan-extraction processes. This mercaptan conversion process has been developed by the Royal Dutch-Shell group and is essentially a modification of the well-known solutizer process for mercaptan removal.

This single-stage treatment of straight-run gasoline with caustic soda removes certain potential contaminants of the solutizer solution. But to avoid sodium contamination, the carry-over of caustic soda must be minimized. To do this, a coalescer is installed ahead of the sweetening equipment and consists of one mixer-settler stage with mixing facilities arranged to provide the correct combination of mixing intensity and contact time. After passing through the settler, a further coalescer completes the removal of the solutizer solution.

Included in the air-solutizer treater are reconcentration facilities for the periodic removal of water from the solutizer solution. This together with the make-up of other constituents maintains the required inventory and optimum composition of the solutizer solution.

Kerosine Acid Treater

The acid treater is equipped with three mixer-settler stages in which kerosine is contacted with sulfuric acid in counter-current flow. These stages are followed by an acid coalescer, one mixer-settler stage for neutralization with caustic soda and a mixer-coalescer for water-washed products.

By maintaining proper conditions during acid treating, a doctor negative product is obtained while substantial desulfurization takes place with comparatively little acid consumption.

Spent caustic and wash water are discharged to the refinery oil catchers via a neutralization pit to which all vessel drains are connected. Acid sludge is routed partly to the waste disposal system and partly to an acid-sludge storage tank.

Waste Disposal

To prevent deleterious and nuisance effects of spent chemicals, a waste disposal plant handles the "sour" water from various water-washing stages in the catalytic cracker, spent caustic soda from the cracked gasoline plant, spent caustic soda from the straight-run gasoline plant, and sulfuric acid sludge from the kerosine plant.

The spent caustic soda from the catalytically cracked gasoline is neutralized batchwise. After dilution with an equal volume of water, the spent caustic is gradually neutralized by a stream of acid sludge from the kerosine treating. The gases are purged by a stream of fuel gas and burned in a waste-products furnace. Neutralization causes the formation of two layers—the oily top layer only is burned and the aqueous bottom layer is transferred to a homogenizing tank.

Into this tank are also drained the "sour" water from the cat cracker and spent caustic soda from treatment of straight-run gasoline. Homogenized tank contents then undergo continuous neutralization with acid sludge from the kerosine treating and subsequent stripping with steam and fuel gas. Neutralized and stripped water, bottom product from the stripper, is discharged to the refinery catchers, and it is part of this water that is used for the batchwise dilution of spent caustic soda from treating catalytically cracked gasoline. The top product from the stripper passes through a condenser for part removal of steam and is then burned in the boiler house or in a waste-products furnace.

Acid sludge not required for neutralization is sold or burned. Sludge burned is first enriched with fuel oil, homogenized, and atomized with steam in a special water-products furnace nozzle.

Utilities

Electrical power is supplied by the Trombay Thermal Power Station. Three boilers at the refinery with a normal capacity of 30 metric tons per hour provide steam at 265 psi and 707 F. Cooling water is taken from the Bombay harbor and pumped to a suction basin. Used on a once-through basis only, it is returned to the harbor at some distance from the intake point.

Tankage is provided for crude, intermediate, and finished products. In addition to the conventional equipment for adding dye, inhibitor, and tetraethyl lead to the finished motor gasoline, facilities are provided for injecting "ICA" as Shell's "TCP" is known outside of the U. S. and Canada.

Before construction could begin, two other engineering jobs had to be completed. One was to move the Bombay Port Trust Railway and the pipe line through which almost all Bombay's white petroleum products were formerly supplied from island-located storage tanks. The other was to reclaim the salt pans that occupied a large part of the site. Only then could actual construction work commence. Further complications were added to the constructors problems when, in 1954, the monsoon seasons set a new record for rainfall recording 170 in. where 70 in. only was considered normal. Even so the refinery was completed in one year less than the scheduled time.

Construction of this and other new refineries in India—the Standard-Vacuum Refinery Company of India, Ltd., which will be adjacent to the Burmah-Shell Refinery on Trombay Island, and that of Caltax (India), Ltd., at Visakhapatnam on the east coast represent a $125,000,000 investment. The greater part of this was provided by overseas investors. * * *

New test method that is simple and gives excellent reproducibility

Determining True Vapor Pressures

William J. Tomsic
Union Oil Company of California
Brea, California

THE Reid vapor pressure method is used by the petroleum industry as a standard test for petroleum liquids. The Reid method is an arbitrary test method that has emanated after considerable test work on various vapor pressure methods. Some of these methods were the Beistle-Prather, Bureau of Explosives, Gard, Reid, and Wade-Campbell.[1]

The Reid vapor pressure is often mistakenly used in place of the true vapor pressure. For pure components, Reid and true vapor pressures should be the same, but for petroleum mixtures, true vapor pressure is generally higher. For some crude oils, true vapor pressure is known to be as much as 1000 per cent higher than the Reid.[2] This is due to the vaporization in the Reid bomb of the highly volatile trace components, methane and ethane, which changes the composition of the liquid whose vapor pressure is being measured. As the quantity of the lightest component present in the liquid is increased, the ratio of the Reid to true vapor pressure will tend to approach unity.

True vapor pressures can be calculated from the fractional analysis of the liquid. Present methods of analysis, however, do not indicate with sufficient accuracy the quantity of highly volatile trace components present in some liquids.[2]

The following test method has been developed for directly determining the true vapor pressure of any liquid. The method is based on the visual determination of the bubble point of the liquid at 100 F.

Presented at California Natural Gasoline Association, Los Angeles.

True vapor pressures for natural gasolines are normally calculated from fractional analysis. For some liquids, such as crude oils, fractional analyses of the highly volatile trace components are difficult to obtain with sufficient accuracy. Reid vapor pressures and true vapor pressures of crude oils are known to differ by as much as 1000 per cent. Hence, the Reid vapor pressure cannot be used in place of the true vapor pressure.

A test method has been developed for determining the true vapor pressure of hydrocarbon liquids. Test consists of superimposing an external pressure on the liquid in excess of true vapor pressure. The external pressure is gradually reduced until the bubble point is reached as determined by visual observation. Results are reported as the true vapor pressure in pounds per square inch at 100 F. Test uses readily available equipment and is simple to conduct. Excellent reproducibility has been obtained.

The test method has been checked against vapor pressures calculated from fractional analysis and from known temperatures and pressures in accumulators with excellent results. A few of the potential uses for the true vapor pressure method are discussed.

Apparatus

(1) A 2 by 6-in. transparent plastic cylinder with two top ⅛-in. pipe connections. Details of the cylinder are given in Fig. 1.

(2) A 5-ft length of ¼-in. Saran tubing with a Schrader check unit and adapter.

(3) A 500 to 1000 milliliter steel scrubber cylinder with two top connections; one connection extending to the bottom of the cylinder.

(4) A pressure gage with a range of 30 in. vacuum to 100 psi pressure.

(5) A mercury manometer with a 30-in. range.

(6) A constant temperature bath controlled at 100 F ± 0.2 F.

(7) Source of 100 psi air pressure.

(8) A vacuum pump capable of producing a vacuum of 1 millimeter of mercury.

The apparatus is assembled as shown in Fig. 2. The valves are numbered to simplify the discussion that follows.

Obtaining Sample

Prior to obtaining the sample several boiling stones are placed in the cylinder. The boiling stones are necessary to agitate the sample, thus preventing supercooling during the testing of the sample.

The plastic cylinder is connected to the source of material to be tested using the Schrader check unit. The sample may be taken from any sample cylinder, tank, or line. Care must be taken not to contaminate the sample with air. The cylinder must not be connected to a source of pressure exceeding the working pressure of the plastic cylinder.

Open the tank or line valve and then open valve 5. Partially open valve 7 and purge the cylinder with at least 5 times its volume. Close valves 7 and 5 and the tank or line valve in the above named order. The sample is

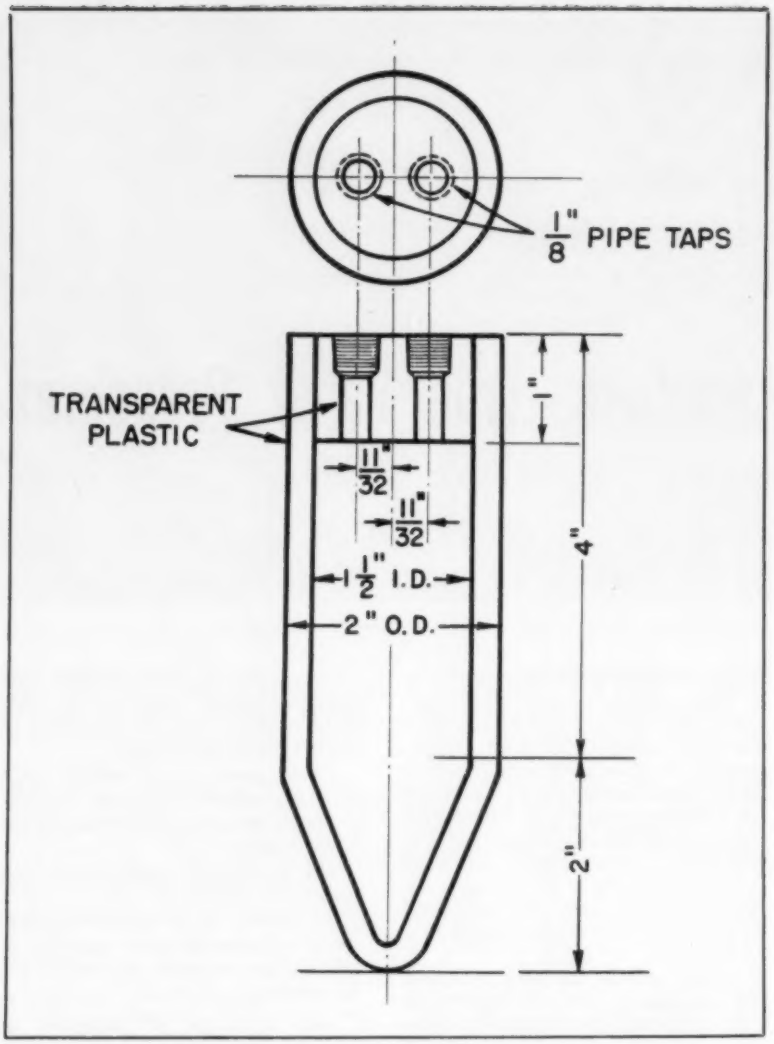

FIG. 1. Cylinder employed in true vapor pressure apparatus.

now ready for testing. Sample must not be allowed to exceed the sampling temperature prior to the testing of the sample.

Determination of Vapor Pressure

Connect the Saran tubing and valve 5 to the steel scrubber using the Schrader check unit and adapter. Open valves 4 and 1. Use valve 3 to pressure the apparatus in excess of the expected vapor pressure. Use the manometer for vapor pressures less than 15 psia. If the vapor pressure is expected to be greater than 15 psia, protect the manometer by closing valve 6 before pressuring with air. Open valve 5 and place the cylinder in the 100 F water bath. The amount of Saran tubing immersed in the water bath is not important.

In setting up the apparatus for measuring very low true vapor pressures, care must be taken to have the cylinder and tubing at the same elevations so that the static head effect is not present.

After 30 minutes have elapsed, crack valve 2, allowing the pressure to reduce gradually. At the same time, continually invert or shake the plastic cylinder under water, allowing the boiling stone to agitate the liquid. Each time the plastic cylinder is inverted, observe the solution for formation of bubbles. When bubbles are noted, close valve 2 and record the indicated pressure on the manometer or pressure gage. If the bubble point pressure was missed by dropping the pressure too rapidly, the apparatus may be repressured. By shaking the cylinder, the bubble will be reabsorbed in the solution. The test can then be repeated.

If the sample has a vapor pressure less than 15 psia, the vacuum pump is used. An increasing vacuum is applied to the scrubber until the bubble point is reached.

As water will boil at about 0.95 psia at 100 F, special precautions are necessary to dehydrate samples containing water. The plastic cylinder is filled with approximately 50 ml of ethylene glycol. The plastic cylinder is then connected to the sample source by neoprene tubing connected to valve 7. A spare Schrader adapter is inserted in the check unit to allow liquid to flow through the Saran tubing. Open valves 7 and 5. Crack valve on sample source and allow material to flow through upright cylinder until the cylinder has been purged with at least 5 times its volume. The glycol will remain in the bottom of the cylinder. Slow the flow to a very low rate and invert the cylinder. Glycol will then flow into the Saran tubing. When the glycol reaches valve 5, shut supply valve and valves 7 and 5. Sufficient glycol will remain in the cylinder to dehydrate the material being tested. The vapor pressure test is conducted in the usual manner.

The results of the test are reported in pounds per square inch of absolute pressure. The manometer readings are converted to pounds per square inch and either added or subtracted from barometric pressure depending on whether a pressure or vacuum reading was obtained. The gage pressure is added to the barometric pressure.

The test method has given excellent reproducibility. The same sample of crude oil has been rerun and the results checked within a few tenths of an inch of mercury.

To verify the results of the test method, samples were run from accumulators whose temperatures and pressures were known. Agreement within one per cent was obtained between the observed and measured vapor pressures. True vapor pressures were also run on samples whose fractional analyses were known. The calculated and measured results checked to within one to two per cent.

Uses of True Vapor Method

The quality of a lean oil influences the absorption of the components in an absorber. Absorber efficiency will decrease as the light ends content of the lean oil is increased. The quality of a lean oil can be determined by the true vapor pressure method.[3,4] The true vapor pressure will indicate the presence of light ends in the lean oil in cases where other control tests will not. In the same manner, the operation of any hydrocarbon stripper or reabsorber can be checked by the true vapor pressure method.

True vapor pressures at different temperatures are needed for process

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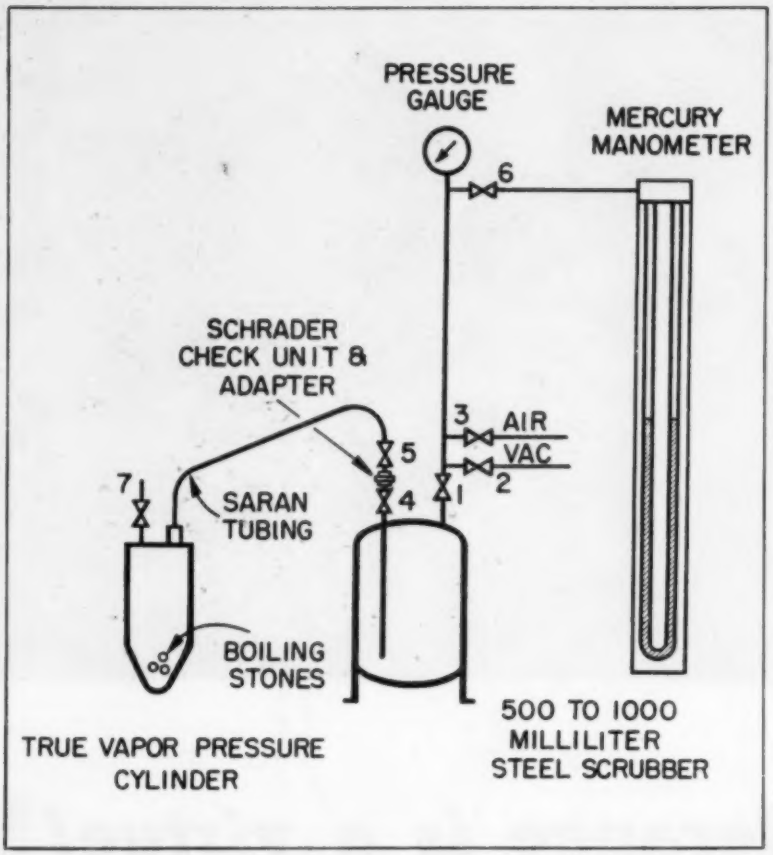

FIG. 2. Flow diagram of entire true vapor pressure apparatus assembly.

design calculations, estimating conditions in accumulators, safety considerations for handling materials, and numerous other uses. The Cox chart is commonly used to determine the change in vapor pressure of hydrocarbons with temperature. The vapor pressure test can be carried out at different temperatures to give a line on the Cox chart. We have found that for some crude oils, the vapor pressure does not increase as rapidly with temperature as predicted by the Cox chart.

Molecular weights can also be approximated by the use of true vapor pressures. It is well known that when two liquids following Raoult's Law are blended together, the resulting true vapor pressure is the sum contributed by each liquid. Each liquid contributes an amount equal to its molecular fraction times its true vapor pressure. A liquid whose molecular weight and true vapor pressure are known can be accurately blended in a second liquid with a known true vapor pressure. The true vapor pressure of the mixture can then be determined. The molecular weight of the other liquid can then be calculated by assuming molecular weights until the observed and calculated true vapor pressures are the same. Or if the molecular weights are known, vapor pressures of the blends of two or more liquids can be calculated if their individual true vapor pressures are known.

Vapor losses from storage tanks are also dependent on the true vapor pressure of the material in the tanks.[5]

Summary

A test method has been developed for the determination of the true vapor pressure of hydrocarbon liquids. The method is simple and gives excellent reproducibility.

Acknowledgment

The test method was developed by Robert A. King of Union Oil Company prior to his death on July 6, 1954. It is hoped that his test method will serve a useful place in the technology of the petroleum industry.

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★ ★ ★

Texas Marks 58 Years of Refinery Growth

From the couple of tubs and the pine tree kindling that was Texas' first oil processing plant, Texas' petroleum refining industry in 67 years has grown into a $2.5 billion manufacturing enterprise.

Texas' 58 operating refineries make up one of the state's major industries, highly competitive, with the key to survival being constant improvement to meet demands of the American consumer, according to the Texas Mid-Continent Oil & Gas Association.

The first oil processing plant in Texas (which operated at Oil Springs, Nacogdoches, in 1888) was little more than a grease plant, boiling off the lighter fluids from the crude oil and using only the heavier lubricants.

The first real Texas oil refinery operated at Sour Lake in 1896, turning out eight different grades of oil. The next refinery at Sour Lake, built two years later, was sold in 1899 for $6385.

In 1898 a $150,000 refinery was built at Corsicana, representing a major step toward marketing finished products of Texas crude oil.

Spindletop was discovered in 1901 and the demand for oil products began to rise. Three refineries were constructed in the Beaumont-Port Arthur district to process Spindletop crude.

In 1912 there were 11 refineries in Texas with total crude capacity of 10,000 bbl daily. West Texas got its first refinery in 1919 and in 1920 a refinery was built at Oil Springs to process the revived area's oil.

Refinery growth was steady and by 1930 Texas refineries were processing over 215,000,000 bbl a year, accounting for 74 per cent of the state's crude production.

Discovery of the East Texas field set off a splurge of refinery building, although the major portion of the field's 80 refineries in 1933 were little more than skimming plants.

Last year, 703,732,000 bbl of crude oil, or 71.7 per cent of the state's production, was processed in Texas. This represents a steady increase in the amount of Texas output refined in the state since 1950, when 67 per cent was processed.

The state's refineries at present have a crude oil capacity of 2,300,000 bbl a day, representing 27 per cent of the nation's refining capacity. Largest of these plants has a capacity of over 300,000 bbl a day, another more than 270,000 bbl, and two others have capacities of 200,000 bbl or more.

Refineries spend millions in modernizing their facilities. One plant last year spent $10,000,000 on one unit.

Petrochemicals Unlimited: From Ethane, Propane, Butanes

Oxygenated Petrochemicals

Peter W. Sherwood
Chemical Engineer

Part IV, Section 2: Ethyl and propyl alcohol, ethylene, styrene oxide

Commercial practice followed in the liquid-phase synthesis of monohydric alcohols is best considered in relation to the specific production of ethanol and isopropanol, the most important members of the series.

Liquid-Phase Synthesis of Ethyl Alcohol. Five major factors have made the liquid-phase hydration economical for ethanol production:

(a) The ease with which higher olefins may be removed from ethylene by absorption in 85 per cent sulfuric acid.

(b) The discovery that absorption of ethylene in sulfuric acid is greatly expedited by the presence of ethyl sulfuric acid.

(c) The discovery of conditions that permit formation of diethyl sulfate in large concentration, thereby reducing acid consumption.

(d) The finding that high pressure results in substantial increase in absorption equilibrium and rate, and

(e) The favorable effect of alcohol elimination from the absorption medium.

Using pure ethylene and 66 deg Bé H_2SO_4, Strahler and Hachtel[7] found that diethyl sulfate formation at equilibrium rises rapidly between 180 and 225 psi system pressure. Above 225 psi, diethylene sulfate content maintains an assymptotic value of 25 per cent (based on absorbed ethylene). Within this range, polymerization of ethylene is insignificantly affected by pressure, so that ethylene partial pressure of 225 psi may be considered an optimum value, at least insofar as equilibrium considerations are concerned. However kinetic studies by Brooks[8] show that absorption rate continues to rise as pressure is raised to 500 psi and possibly above.

At 225 psi and 66 deg Bé sulfuric acid, ethylene absorption rises markedly with temperature until it reaches an assymptotic value (approximate 120 per cent of theoretical ethyl sulfuric acid) at 65 to 70 C.

Ethylene absorption is very markedly influenced by acid concentration. Thus, Brooks[8] was able to absorb 1.56 moles ethylene per mole H_2SO_4 at 97.5 per cent strength (50 C, 45 deg psi). In 95 per cent H_2SO_4, absorption stopped after 1.28 moles ethylene had been introduced. At the same time, absorption rate was significantly boosted by acid strength.

Various catalysts have been proposed to expedite the esterification process. Limited value is found in their use (*e.g.*, 10 per cent Ag_2SO_4), but they have not been reported in industrial application. Such catalysts do not affect the total amount of ethylene absorbed at equilibrium, but they do influence the per cent diethyl sulfate formation.

Hydrolysis is effected by water dilution (to approximately 50 per cent) and at the boiling point of the system. Ammonia is on occasion used as hydrolysis aid (which will lead to the formation of by-product ammonium sulfate). More commonly, such aids are avoided and spent sulfuric acid is re-concentrated.

Crude alcohol is taken overhead as it is formed. It is accompanied by about 5 per cent ether, a product primarily of diethyl sulfate hydrolysis, and an important saleable by-product of the alcohol process. The overhead vapors are caustic-scrubbed for elimination of contained acids. They are then condensed and taken to crude alcohol storage ready for distillative purification of product alcohol and ether. Overall yield of alcohol is 85 to 88 per cent based on absorbed ethylene. Industry-wide, average yield of 95 per cent ethyl alcohol is reported to be 0.23 gal per pound ethylene gas (86 per cent of theory) and 0.65 gal/gal ethyl sulfate.

Liquid-Phase Synthesis of Isopropyl Alcohol. For esterification of propylene, the optimum sulfuric acid concentration is between 75 and 85 per cent. Ideally, the monohydrate of sulfuric acid (84 per cent) would be most desirable, since operation at this concentration would cause no build-up of free water with its concomitant adverse effect on absorption rate as the reaction progresses. Actually, side reactions that occur to a significant extent modify this picture and provide the reason for selection of lower acid concentrations.

Foremost among these secondary reactions is the formation of diisopropyl sulfate. This intermediate is itself susceptible to conversion to isopropanol upon hydrolysis, and while its occurrence reduces over-all acid consumption, it also leads to the production of diisopropyl ether in significant amounts. Unless markets for this by-product are assured in adequate volume, its formation must therefore, be suppressed by operating with more dilute acid. It has been shown[9] that diisopropyl sulfate cannot be formed in the presence of any appreciable amount of free water.

The main reaction system is controlled by the equilibrium between propylene, isopropyl sulfate and isopropanol. Even in acid of 80 per cent strength, only about 35 per cent of the

EXCLUSIVE

absorbed propylene will be present as the sulfate[10] if an acid: hydrocarbon ratio of 1 is used. The percentage of propylene present as sulfate drops sharply as the acid is diluted and is only about 4 per cent at 45 per cent acid strength. This shift in equilibrium is, of course, the basis of the commercial two-step process.

According to Schrage and Amick,[10] conversion of propylene to isopropyl alcohol is surprisingly independent of hydrocarbon:acid ratio. Formation of isopropyl ether, however, passes through a maximum value at mole ratios of 0.6 to 0.8, with consequent drop in propylene efficiency.

Use of elevated pressure raises the absorption rate and thus permits operation at lower temperatures and acid concentration than would otherwise be feasible.[11] Prime advantages of this mode of operation are the repression of polymerization reactions and of sulfone formation, and avoidance of alcohol dehydration (*i.e.*, reversion to propylene). Furthermore, use of pressure permits operation entirely in the liquid phase.

An operating pressure of 300 psi is reported for the absorption unit at Rheinpreussen, which serves for the first step in the production of isopropanol and s-butanol from a propene-butene mixture.[12] At this plant, incidentally, the sulfation reaction is, or has been, carried out in batch autoclaves. Most other plants operate on a continuous basis.

Here, the hydrocarbon feed is a C_3-C_4 fraction containing approximately 10 per cent propene and 27 per cent butene-2 (almost no isobutylene). This mixture is compressed and liquefied and is then contacted with 75 per cent sulfuric acid in agitated autoclaves. The reaction is started at room temperature but is allowed to rise to 60 C.

Contact time is about 1 hr. At the conclusion of this period, substantially all the propylene has been absorbed while some 8 per cent of the butylene remains unconverted in the hydrocarbon phase. Polymerization of butene accounts for nearly 22 per cent of this olefin. Propylene is, of course, much less prone to polymerization, and losses due to this side reaction are not serious. At the conclusion of the esterification reaction, the charge is removed from the autoclave and residual hydrocarbon is separated from the acid layer.

Hydrolysis of Isopropyl Sulfate. The extent of dilution required for full hydrolysis increases with the molecular weight of the alcohol. At the Rheinpreussen plant, where s-butanol is produced together with isopropanol, enough water is added to reduce acid concentration to 25 per cent (for isopropanol production alone, final concentration of 30 to 40 per cent would be adequate).

In the first dilution step, acid strength is taken to 30 per cent. The diluted acid phase is fed continuously to a cascade of four carbon-lined hydrolizers, each provided with an internal baffle. Live steam is admitted to each hydrolizer, and evolved vapors are collected in an overhead main connecting the four units.

Reaction temperature in successive hydrolizers is 80, 95 and 100 C, respectively. The last vessel, in which an acid concentration of about 25 per cent prevails, is operated at the boiling point of its contents. Effluent acid is substantially free of alcohols or esters and may be taken directly to the reconcentration stage.

The overhead from the hydrolizers is cooled for condensation of the alcohols. No propylene is found in the gas phase. Some butene, however, is formed at the acid concentration provided. For its complete elimination, final acid content would have to be taken to uneconomically low values.

The condensate consists primarily of the desired alcohols and water plus about 5 per cent ether (based on alco-

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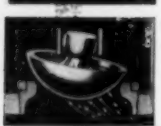

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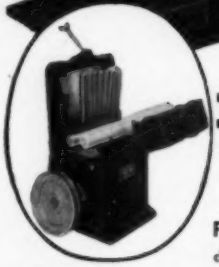

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January ★ One of a Series of Interest to the Petroleum Industry ★ 1956

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For more information on these and other dealer meeting aids, just get in touch with any of our sales offices. Ask for a copy of "Sales Promotional Aids for Dealer Meetings."

WHO is your "typical" dealer . . . and HOW does he operate?

Many important facts about the man and his business are revealed in Report No. 4 of Du Pont's continuing market survey, "The Service Station Operator"

Thousands of customers form, confirm, or change their opinions of your company every day . . . based on the impressions made by your service station operators. Because of this, a composite, cross-section picture of the average dealer can be valuable to you in formulating dealer policies and sales promotion plans.

"The Service Station Operator" is a new Du Pont survey designed to give you a clear, concise picture of the average American dealer . . . his employees, his business, his opinions, his background, his relation to his petroleum products supplier, and his motivations. Three reports on this survey have already been published and made available to marketers by the Du Pont Petroleum Chemicals Division.

They cover (1) such dealer retail functions as station hours, gallonage, credit and mailing lists; (2) dealer knowledge of products, additives, sales assets, and prices; and (3) opinions on dealer meetings, advertising, dealer publications, and sales aids.

Report No. 4

The fourth report in the series, which has just recently come off the press, discusses the dealer's relationship with employees, his income and reactions to price wars, and his interests in dealer association activities.

The statistics included in the report are graphically illustrated with charts and are enlivened by cartoon drawings. This format makes the important points easy to reach, remember, and refer to.

What happens when . . .

For example, how does the average dealer react to a price war in his own marketing area? That is one of the factors influencing your business which is covered in Report No. 4.

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OVER

PETROLEUM CHEMICALS DIVISION
NEWS

CONTINUED *"Dealer Survey"*

What's next?

A fifth report on "The Service Station Operator" survey is due to be published soon. This will be the most significant of the whole series of reports. It will discuss the interrelationships of all the factors covered in previous reports . . . such as how dealer meetings, station hours, price wars, and other variables affect sales volume.

As part of the continuing market research work of the Du Pont Petroleum Chemicals Division, this dealer survey is the natural follow-up of an earlier survey on the buying habits of consumers at service stations. The interviews were conducted on a completely impartial basis by National Analysts, Inc.

Specialized cross-tabulations

Based on personal interviews with 2,633 service station operators – selected by the scientifically accurate area-sampling method – the survey is representative of all the operators in the United States. But the results can be broken down and cross-tabulated to give a true sample of any of four geographical areas.

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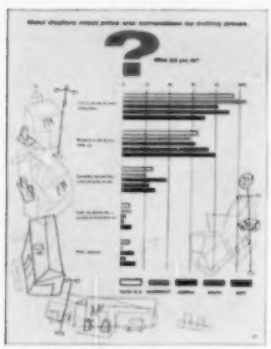

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John N. C. Cameron, manager of the Du Pont Petroleum Chemicals Division's regional laboratory in Houston, Texas, is in charge of customer service, product testing and additives treating recommendations for Du Pont customers in the Gulf Coast Region.

Before joining the Du Pont Company in 1949, Mr. Cameron was with the Research and Development Division of Humble Oil and Refining Company at Baytown, Texas. During his seven years with this company he worked as a research chemist on octane rating and light oil analytical research. He also did pilot scale research on catalytic treating. Prior to his assignment at Humble, he was employed for three years by the Gravity Meter Exploration Company in Houston.

After starting his college career at the University of Texas, he transferred to the University of Houston, where he received his B.S. degree in chemistry.

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col). The ether is topped off (and extracted with water for recovery of contained alcohol). Alcohol is then freed of most of the contained water by straight fractionation. Azeotropic distillation (with benzene) serves for final drying of the alcohol.

Vapor-Phase Synthesis of Monohydric Alcohols. The classical liquid-phase process for alcohol synthesis is beset by numerous drawbacks. Acid losses are appreciable and costs of reconcentration are significant. There are also severe handling problems and corrosion difficulties. It is, therefore, natural that many attempts have been made to hydrate olefins directly in the presence of a fixed-bed catalyst. This work came to fruition in 1948, when Shell Chemical Company began direct hydration of ethylene at Houston. Since 1951, England's Imperial Chemical Industries has been using direct hydration in the vapor phase for isopropanol production. During the same year, British Petroleum Chemicals, Ltd., began production of ethanol by the Shell process at Grangemouth.

$$R{-}CH{=}CH_2 + H_2O \longrightarrow R{-}\underset{\displaystyle OH}{\underset{|}{CH}}{-}CH_3 \quad \ldots (4)$$

Direct hydration of olefins is an equilibrium reaction. Conversion to the alcohol is favored by the use of low temperatures, high pressures and high steam:olefin ratio. To achieve maximum conversion at any temperature, thermodynamic considerations, dictate operation at a pressure only slightly below the saturation point. If this condition is fulfilled, the temperature itself may be varied over wide limits with only relatively minor effect on the equilibrium position.

Of the numerous catalysts claimed for the direct hydration, only two — supported phosphoric acid and promoted tungsten oxide — are so far of commercial interest. In the Shell ethanol process, phosphoric acid on Celite is employed. Activity of this catalyst is adversely affected by moisture absorption at elevated pressure and at high steam:olefin ratios. Rise in temperature has a favorable effect on catalyst activity, but unless compensating adjustments are made in the other process variables, the equilibrium is shifted to lower possible ethanol concentration in the product.

Thus activity of the phosphoric acid catalyst is a variable dependent on other process conditions. It is adversely affected by conditions that favor ethanol formation and operating conditions are chosen on the basis of economic compromise. Nelson and Courter[13] report that ethylene conversion in the Shell process is 4.2 per cent (about one-third of equilibrium conversion). A high recycle ratio is, therefore, required, which necessitates the employment of a concentrated ethylene make-up. Design in the Shell process calls for make-up ethylene of 97 per cent purity. Recycle ratio and purity is controlled to maintain a blended reactor feed of 85 per cent (water-free basis). This stream contains 0.6 moles water per mole ethylene. Reactor conditions are 1000 psi and 300 C and a space velocity of 30 SCFM gas per cubic foot catalyst. In the face of catalyst loss by entrainment or vaporization, activity is kept up by injection of make-up phosphoric acid into the reactor feed stream.

Special interest attaches to the purification method employed in the Shell process. The reactor effluent is cooled and part condensed. It is then scrubbed with caustic for the removal of contained phosphoric acid. After phase separation, the vapor stream is further cooled and water scrubbed for alcohol recovery before it is recycled to the reactor system. A small bleedstream is continuously taken from the recycle in order to control impurities build-up.

The combined condensate from the coolers and scrubbers is first concentrated in a stripping step. The organic concentrate (which is taken overhead in the stripping operation) is subjected to hydrogenaton over a supported nickel catalyst. The purpose of this step is to convert side-product acetaldeyhde (derived mainly from acetylene in the feed hydrocarbon) to ethanol. At the same time, present higher aldehydes are hydrogenated to their corresponding alcohols, which are less troublesome in the final distillation steps. After separation from gaseous hydrogen, the treated product is sent to fractionation where separation and purification of by-product diethyl ether and, above all, 95 per cent ethanol is effected.

Very promising (though not yet commercialized) results are obtained in the direct hydration of olefins over promoted tungsten oxide on silica gel carriers. In the presence of such catalysts, Mace and Bonilla[14] have recently reported up to 6.8 per cent per pass yield ethanol at 300 C, 2000 psi, steam: ethylene ratios of about 1.0, and space velocities of 1500 hr^{-1}. Catalyst activity is controllingly influenced by WO_3 content (optimum at 15 to 18 per cent) and by activation temperature (which must be less than 425 C and is best at about 315 C). Quite possibly, these results could have been further improved by raising the steam:olefin ratio at otherwise optimum catalytic conditions.

For the hydration of propylene, Runge et al[15] evaluated some 120 catalysts and found the best promise in promoted tungsten oxide (although good results were also obtained with supported phosphoric acid). Tungsten oxide catalysts retained full activity after more than 1000 hr on stream. Conversion of 88.8 per cent (approximately 40 per cent of equilibrium) and yields of 94 per cent were readily obtainable at 80 to 200 atm and 260 to 320 C. Condensate contained 34 per cent alcohol. Surprisingly, a significant proportion of the by-product was n-propanol in addition to the expected diisopropyl ether and polymerization products.

Catalysts in this category have had successful pilot plant runs at Gendorf, where the preferred catalyst was zinc oxide-promoted 20 per cent tungsten oxide on silica gel that had been reduced in a stream of hydrogen[16]. With this catalyst, the optimum hydration temperature is 225 C. Operating pressure is 100 to 200 atm. Little is gained by further boost in pressure while losses to polymerization increase.

In the work at Gendorf, some liquid water was allowed to be present in the reaction zone so that the system was completely saturated at all points of the reactor (this thermodynamic ideal requires a rugged catalyst). The trickle technique, employing parallel flow of the two phases, was used.

With this catalyst, it is possible to obtain an average of 0.8 kg isopropanol per liter catalyst per day. Ultimate alcohol yield is 94 to 95 per cent. The condensate contains up to 20 per cent isopropanol, which can be readily upgraded to pure isopropanol or to the azeotropic composition (91 per cent) by standard distillative means.

Production of Epoxides by Saponification

By action of caustic, hydrogen chloride may be eliminated from chlorohydrins for the production of the corresponding epoxides:

$$R{-}\underset{\displaystyle OH}{\underset{|}{CH}}{-}CH_2{-}Cl \xrightarrow{\text{(Caustic)}} RCH\underset{\displaystyle O}{\underset{\diagdown\,/}{}}CH_2 \quad \ldots (5)$$

This saponification reaction figures most prominently in the production of ethylene oxide, propylene oxide and propylene epichlorohydrin. Synthesis of the intermediate chlorohydrins has

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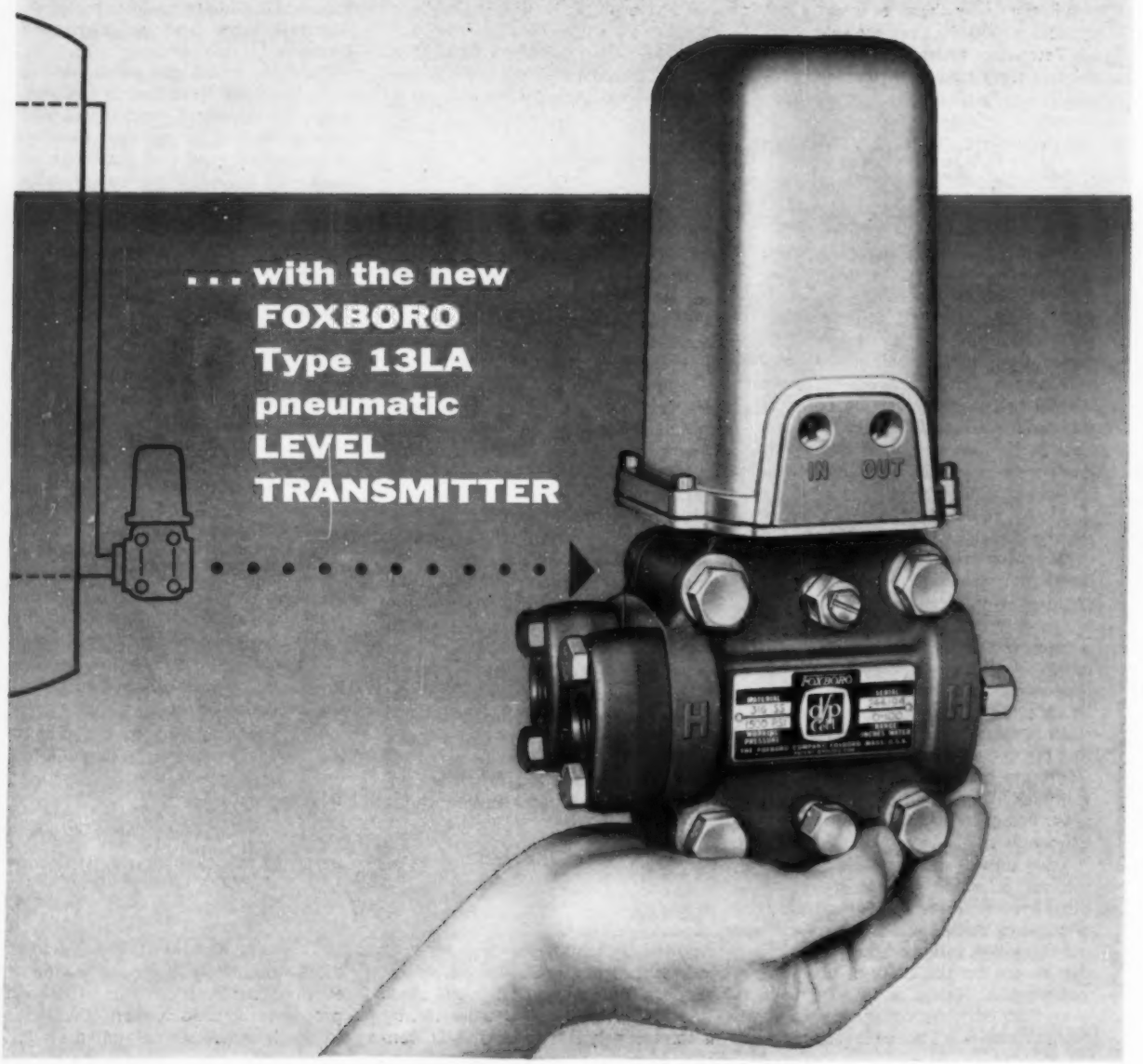

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been discussed in Part III of this article series.

Production of Ethylene Oxide and Propylene Oxide. Market importance of ethylene oxide has been discussed above in connection with the direct oxidation process, which today vies with the ethylene chlorohydrin route for first position among methods of ethylene oxide synthesis. Propylene oxide, on the other hand, is produced exclusively by the classical method via propylene chlorohydrin. This product is important as basis for the production of propylene glycol, an industrial antifreeze. (Estimated 1954 production is 68,000,000 lb.) Also important is the hydrogenation of propylene oxide to n-propyl alcohol, a commodity that is otherwise available only as one of many products formed in the course of direct oxidation of hydrocarbons (q.v.).

Ethylene Oxide. In the industrial production of ethylene oxide, the saponification is generally carried out on the dilute solution received from the ethylene chlorohydrin unit. Treatment with sodium hydroxide results in the formation of appreciable quantities of undesired dichloro-ethyl ether. A more suitable reagent from the point of view of yield is sodium carbonate or limestone (which leads preferentially to ethylene glycol) or lime (for the intermediate formation of ethylene oxide). The latter reagent is used even where the ultimate objective is the formation of glycol. A two-step process for the conversion of ethylene chlorohydrin is thus made necessary, which has, however, the advantages of using an inexpensive alkali and of permitting higher glycol yields than are possible in single-stage conversion.

Lime is generally employed as an aqueous slurry containing 10 per cent CaO. Certain impurities in lime, notably magnesium, tend to promote the formation of yield-consuming acetaldehyde and may, therefore, be present in low content only. A slight excess of lime above theoretical requirements is maintained in order to ensure complete recovery of ethylene oxide and prevent the occurrence of corrosive conditions.

The reaction between milk of lime and dilute chlorohydrin solution is generally carried out continuously. The equipment consists of vertical or horizontal cylinders provided with internal baffles to prevent mixing of feed and product streams and to assist in maintaining uniformity at any cross-section of the reaction stream. Agitation is provided by the introduction of live steam into the system.

The mixed feed enters at one side of the reactor, where it is soon heated to 95 C by live steam. In the early stages of the reaction, the temperature is maintained at this point in order to prevent excessively fast development and evolution of ethylene oxide, which may result in operating difficulties due to frothing and splashing. Eventually the temperature is allowed to rise to 100 C to complete the hydrolysis. Normal hold-up time in the hydrolizer is 15 to 30 min. The reaction is carried out at slightly positive pressure.

A dephlegmator, superimposed on the reactor, returns any volatilized ethylene chlorohydrin and most of the evolved steam to the reactor, while permitting the passage of ethylene oxide, ethylene dichloride and some steam. This gas stream, containing about 40 per cent ethylene oxide, is the desired product. It is cooled to 25 to 30 C, and the condensate formed thereby is separated from the residual gas phase. Both phases are introduced into a primary distillation column at different plates. In this fractionation unit, a cut is made between ethylene oxide and water. To avoid hydrolysis at this stage, vacuum operation is chosen.

Ethylene oxide, removed as overhead product of the primary distillation column, is subjected to a second distillation for purification purposes. Over-all product yield is 90 to 95 per cent (based on ethylene chlorohydrin).

Typical over-all raw material consumption in the production of one pound ethylene oxide by the chlorohydrin route calls for .91 lb ethylene to .14 lb chlorine and 2.0 lb milk of lime (100 per cent CaO).

Ethylene Glycol. Quite commonly, ethylene oxide is hydrolized to its main product ethylene glycol while still in dilute aqueous solution. As in the case of ethylene oxide produced by direct oxidation (vide supra), the hydrolysis may be effected by dilute (1 per cent) sulfuric acid. Certain advantages have been claimed for the use of oxalic acid in this connection.

Alternately, conversion may be carried out in the absence of acid but at temperatures requiring pressure operation. This method is particularly suitable for the product of the chlorohydrination process, which is not too dilute. A chief advantage of the pressure process is its operability in carbon steel equipment.

Ethylene oxide is diluted with about six times its weight of water and is allowed to react at 190 C and about 200 psi. Residence time is about 1 hr. The reaction product is delivered to a multiple-effect evaporator in which it is concentrated to 90 per cent glycol. Final dehydration is carried out by vacuum distillation. Secondary stills separate ethylene glycol from diethylene and triethylene glycol.

The conversion of ethylene oxide to glycols in this reaction is essentially complete. Formation of higher glycols reduces the yield of ethylene glycol to about 92 to 95 per cent.

Propylene Oxide. Saponification of propylene chlorohydrin to propylene oxide is effected at conditions that substantially parallel the corresponding formation of ethylene oxide. Here, too, milk of lime is used that may not contain more than 1 per cent MgO, lest propionaldehyde formation become excessive.

The reaction rate in propylene oxide formation is substantially less (of the order of ten times) than that observed in ethylene oxide formation. It has been found, however, that the major brake on product formation in the case of the propylene compound is the presence of product in the reaction medium.[17] It is, therefore, possible to speed up the reaction to industrially feasible rates by facilitating and accomplishing the removal of product from the system as rapidly as it is formed.

Production of Epichlorohydrin and Styrene Oxide. *Epichlorohydrin.* Glycerol dichlorohydrin (see Part III of this series) finds it most important application as intermediate in the production of glycerol. This conversion may be carried out by caustic hydrolysis, as will be discussed below in the present chapter. By treatment with lime, the dichlorohydrin may be saponified to propylene epichlorohydrin

$$Cl{-}CH_2{-}\underset{\displaystyle OH}{\underset{|}{CH}}{-}CH_2Cl \xrightarrow{Ca(OH)_2} Cl{-}CH_2{-}\underset{\displaystyle O}{\underset{\diagdown\,\diagup}{CH}}{-}CH_2 \quad \ldots (6)$$

The product may be converted to glycerol. In recent years, epichlorohydrin has shown very significant independent growth as one raw material in the production of epoxy resins. Since these resins were first introduced in 1946, a market has been developed for them that is estimated at 30,000,000 lb in 1954. At present, their primary use is in the manufacture of enamel-type finishes (home appliances, drum linings, etc.) and of floor varnishes. Certain structural plastics consume some 15 per cent of epoxy resins, but fuller realization of this very large potential market is still hampered by relatively high raw materials price. Typically, epoxy resins are produced by polymerization of epichlorohydrin with bisphenol-A (4,4′ — isopropylidene-diphenol) in a ratio of 1:4.

Epichlorohydrin may be produced by treating crude glycerol dichlorohy-

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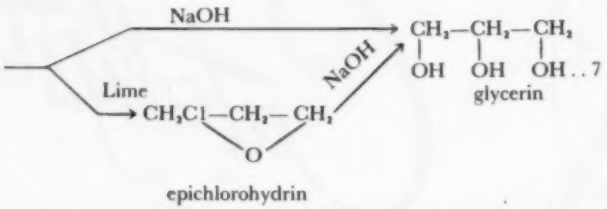
drin with lime in the base of a stripping column. The product is taken continuously overhead.

Styrene Oxide. A recent newcomer to the field of petrochemical epoxides is styrene oxide, which Dow Chemical Company introduced commercially in late 1953. Like ethylene oxide, this compound is produced by the saponification of the parent chlorohydrin. In this instance, however, the pure chlorohydrin cannot be so readily produced and purified, and it is unavoidably accompanied by the presence of styrene dichloride. Treatment with strong alkali would convert this contaminant to W-chlorostyrene, which can be separated from styrene oxide only with difficulty. According to Frisch,[18] this objection can be overcome by saponifying the crude chlorohydrination product with calcium acetate. The reaction is preferably carried out at approximately 80 C in ethanol solution. At the resulting buffered alkaline conditions, styrene dichloride itself is also converted to styrene oxide. An over-all styrene oxide yield of 83 per cent of theory is reported in this treatment of a chlorohydrination mixture containing 45 per cent styrene chlorohydrin, 45 per cent styrene dichloride and 10 per cent polystyrene.

$$C_3H_6 \xrightarrow{Cl_2} CH_2{=}CH{-}CH_2Cl \xrightarrow{HOCl} CH_2Cl{-}CH(OH){-}CH_2Cl$$

allyl chloride — glycerin dichlorohydrin



epichlorohydrin

Substitutive Hydrolysis of Chlorinated Compounds

In this category, we include reactions in which the elimination of hydrogen chloride from an organic molecule (saponification) is accompanied by introduction of an OH- group in lieu of the chlorine atom.

Among C_2-C_4 aliphatics, the outstanding commercial examples of this reaction are the production of glycerol, allyl alcohol and amyl alcohol.

Glycerine. Synthetic glycerine capacity in late 1954 has been estimated at 85,000,000 lb (as the result of a 25,000,000 lb expansion program during the year). Total glycerine output during 1954 was approximately 225,000,000 lb. Some 38 per cent of the market is in the production of alkyl resins and ester gums. Sixteen per cent are consumed by the tobacco industry and a nearly equal amount in the manufacture of explosives. The remainder goes to cellophane production (14 per cent), cosmetics and drugs, food processing and miscellaneous other uses.

In this field, synthetic glycerine production has proved an important stabilizing factor. The process is carried out at Shell Chemical's Deer Park plant, which manufactures this polyhydric alcohol from propylene on an integrated basis. Nitro glycerine is also manufactured by Dow Chemical Co.

Production methods for allyl chloride and glycerol dichlorohydrin have been discussed in Part III of this series and manufacture of epichlorohydrin is covered in the present section.

For direct conversion of glycerol dichlorohydrin to glycerin, the use of lime is not suitable because the product cannot be successfully distilled from by-product calcium chloride. The reaction may be carried out in good yield (better than 90 per cent) by contacting the crude dichlorohydrin with aqueous alkali containing 10 per cent NaOH and 1 per cent Na_2CO_3. In the hydrolysis of the monochlorohydrin, the preferred operating temperature is 150 C with a contact time of 30 min. Similar conditions are used in the hydrolysis of dichlorohydrin.

An alternate route to glycerin via the epichlorohydrin permits the replacement of about one-half of the caustic soda by cheaper lime. Glycerol epichlorohydrin (viz. sup.) is readily hydrolized to glycerol by treatment with caustic soda and soda ash.

In either production method, the crude glycerol is concentrated to 85 per cent strength in flash evaporators. Further purification to 99 per cent purity is effected by a combination of solvent extraction (with xylene) and vacuum fractionation.

Allyl Alcohol. Production of allyl alcohol from allyl chloride is the first step in an alternate route to glycerin, which is not, however, used in commercial synthesis. This alcohol, however, has important outlets in the production of diallyl phthalate (a raw material for certain thermosetting resins). Other allyl alcohol derivatives of importance include allyl chloroformate (a resin intermediate), allyl acrylate and methacrylate (cross-linking agents in the production of certain plastics). The alcohol also serves as intermediate in the manufacture of a number of medicinal, perfumery and flavoring compounds.

Equation 8 underlies the hydrolysis of allyl chloride to the corresponding alcohol:

$$CH_2{=}CH{-}CH_2{-}Cl + NaOH \longrightarrow CH_2{=}CH{-}CH_2{-}OH + NaCl \quad \ldots (8)$$

The reaction is carried out continuously at 150 to 160 C. A. pressure of about 200 psi is necessary in order to maintain a liquid phase. The allyl chloride concentration in the aqueous solution is of greatest importance. If it is too dilute, the reaction equipment will be unduly large and recovery costs of the alcohol may well become excessive. On the other hand, a concentrated solution will result in large formation of diallyl ether. The optimum concentration is determined by compromise and is about 1.25 N, *i.e.*, corresponding to about 5 per cent NaOH as the hydrolizing medium.

Of outstanding importance is the alkalinity of the solution. By using sodium carbonate instead of sodium hydroxide, the ether formation is successfully repressed well below 10 per cent. The evolution of CO_2 results, however, in undesirably high pressure. Only a small amount of sodium carbonate is, therefore, employed, and the proper pH is restored by successive additions of caustic soda to keep CO_2 in solution. An alcohol yield of more than 90 per cent can be obtained. The allyl alcohol is readily recovered in its azeotropic (71 per cent) composition by simple stripping. Diallyl ether goes overhead together with the product.

The crude product is dehydrated by azeotropic distillation, using diallyl ether as entrainment agent. The dried crude alcohol is purified by fractionation.

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LP-GAS sales in 1955 increased by a whopping 880,467,000 gal which is the largest increase ever in the 33-year history of the industry. This represents a 17.2 per cent gain over 1954 and is remarkable when one con iders that the industry has been characterized by phenomenal growth. This increase caused total sales to soar over the six billion gallon mark to an estimated 6,006,000,000 gal.

. . . . . **DOMESTIC AND MOTOR FUEL,** up 15.3 per cent to 3,661,000,000 gal. House heating is the largest domestic use — motor fuel gains are impressive.

. . . . . **INDUSTRIAL AND MISCELLANEOUS,** increased by 7.3 per cent to total of 431,000,000 gal. LP-gas proved its versatility by advancing in spite of continued natural gas extensions.

. . . . . **GAS MANUFACTURING,** decreased by 10.9 per cent to a total of 171,000,000 gal to continue trend started in 1951.

. . . . . **CHEMICAL MANUFACTURING,** use of LP-gas even outstripped the up-swing in the chemical industry by advancing 20.2 per cent for a total of 1,262,000,000 gal.

. . . . . **SYNTHETIC RUBBER,** use of LP-gas for manufacture of synthetic rubber components, under stimulus of private ownership and record auto production registered biggest single category increase, 56.3 per cent for a total of 481,000,000 gal.

The chemical and motor fuel increases are significantly large. New uses continue to be found. Production, storage and transportation facilities keeping pace. Outlook for 1956 is for continued growth — another record year.

Domestic and motor fuel

The domestic and motor fuel market for LP-gas in 1955 is estimated at 3,661,000,000 gal for an increase of 15.3 per cent over 1954. This increase of 487,000,000 gal exceeds the entire industry sales in 1941. House heating, which is the biggest single factor in the domestic growth, is spreading rapidly northward as people become acquainted with the cleanliness and convenience of LP-gas. Expansion and extensions of natural gas lines does cause some temporary dislocation of LP-gas customers though it helps by showing more people the advantages of gas and the net effect is that more people want LP-gas. Central heating is on the upswing, especially in new housing units.

Further indication of the trend toward house heating and larger individual users is the fact tank sales are up about 25 per cent. As contrasted to 1954, the summer sales of LP-gas held up much better. The switch to LP-gas for tobacco curing and crop dehydration continues. LP-gas, having already established itself as the ideal fuel for plumbers pots, now finds a growing market as the best fuel for tar and asphalt kettles. LP-gas for weed burning and weed control is definitely picking up and should not be overlooked as a good load-builder. It is estimated that there are between 6500 and 7000 LP-gas bulk plants in the United States.

The use of LP-gas for motor fuel is one of the fastest growing uses. It is estimated that 671,000,000 gal of LP-gas were used in internal combustion engines in 1955. This is a 22.6 per cent increase and represents about 11 per cent of the total industry sales. Motor fuel gains were significant in nearly all parts of the country. The biggest users are: Trucks, tractors, buses, irrigation and drilling engines.

There are now over 250,000 LP-gas tractors in the United States. LP-gas tractor conversions were up 71 per cent for the first six months and carburetor sales (excluding those for tractors) were up 87 per cent. In some areas, dealers report that LP-gas tractors are outselling gasoline or diesel units ten to one.

Truck fleet operators are changing to LP-gas as service station facilities become more numerous and accessible. Recent surveys show over 3350 locations where LP-gas motor fuel service is available. Taxicab fleets are

C. R. Benz P. W. Tucker W. F. DeVoe

also being converted. Truck fleet operators are interested in LP-gas for more reasons than lower oil consumption, less ring wear and more mileage between overhauls. LP-gas is proving to be the answer to cargo refrigeration and cargo heating. Cities are finding it advantageous to convert their road rollers and garbage trucks to LP-gas. Ready-mix type concrete trucks are finding LP-gas doubly advantageous because it is as desirable for the small motor which turns the mixer as it is for the large truck motor — easier to fuel and maintain.

The interest in LP-gas for industrial tractors and lift trucks which really made tremendous gains in 1954 continued in 1955. The fact that maintenance is reduced and that there are less noxious odors in the LP-gas engine exhaust are only two reasons why many fleets of such units are being converted to LP-gas. Most of the larger lift-truck manufacturers now offer U.L. approved factory-equipped models. Aircraft and auto manufacturers, airlines, steel mills, food processors, chemical plants, lumber mills are only a few of the larger industries who are converting their materials handling equipment to LP-gas.

The use of LP-gas for irrigation pumps continues to increase in spite of the advances of natural gas in this market. A recent survey of 33,537 irrigation wells in the high plains area of Texas showed that 46 per cent used LP-gas, 35 per cent used natural gas and the remainder either gasoline, diesel fuel or electricity.

Practically all major LP-gas appliances show a healthy sales increase this year. LP-gas range sales increased an estimated 11 per cent for a total of 455,000. Sales of automatic LP-gas water heaters are estimated at about 350,000 — almost 13 per cent over 1954. LP-gas warm air furnace sales are estimated at 71,800 or 8.4 per cent of the total of this type of gas appliance. Direct heating appliances and recessed wall units total 286,900—19 per cent of the total of this type appliance. LP-gas floor furnaces represented 25 per cent of the total, or 40,000 this year.

Industrial and miscellaneous

The demand for LP-gas for industrial and miscellaneous uses totalled 431,000,000 gal which is an increase of 7.3 per cent over 1954. Though natural gas took over some of this market, the increased level of overall business activity and new applications kept this market on the increase. LP-gas for flame cutting is making gains. One interesting new market is the use of LP-gas in uranium refinery operations. Stand-by plants are being added to take advantage of interruptable rates and as a protection against winter-shut-down. The severity of the winter, however, is the determining factor in this latter market.

Gas manufacturing

The utility use of LP-gas is estimated at 171,000,000 gal or a decrease of 10.9 per cent as compared to 1954. The swing to natural gas is the story here though L-P-gas is proving popular in new housing developments. There is an important industry development though in the increased cooperation between gas utility companies and the LP-gas industry. More joint gas promotion was seen in 1955 than any year in history. This will doubtless continue with increased benefits to all.

Chemical manufacture

Sales of LP-gas as a raw material for the manufacture of chemicals and chemical intermediates showed 20.2 per cent increase over 1954 with an estimated volume of 1,262,000,000 gal. This increase can be attributed to the rapid growth of the petrochemical industry and to the high rate of industrial activity throughout the year. The increased demand for ethylene resulted in large volumes of LP-gas being used to supplement ethane as a base material. This trend should continue into 1956 as large ethylene and polyethylene plants now under construction are placed in operation.

New processes for the manufacture of glycerine and phenol from propylene and the production of nitro paraffins and its derivatives, primarily from propane, were highlights in new uses of LP-gas that developed during the year. Furthermore, propane and butane will probably remain for some time the most efficient and economic raw materials for oxygenated chemicals.

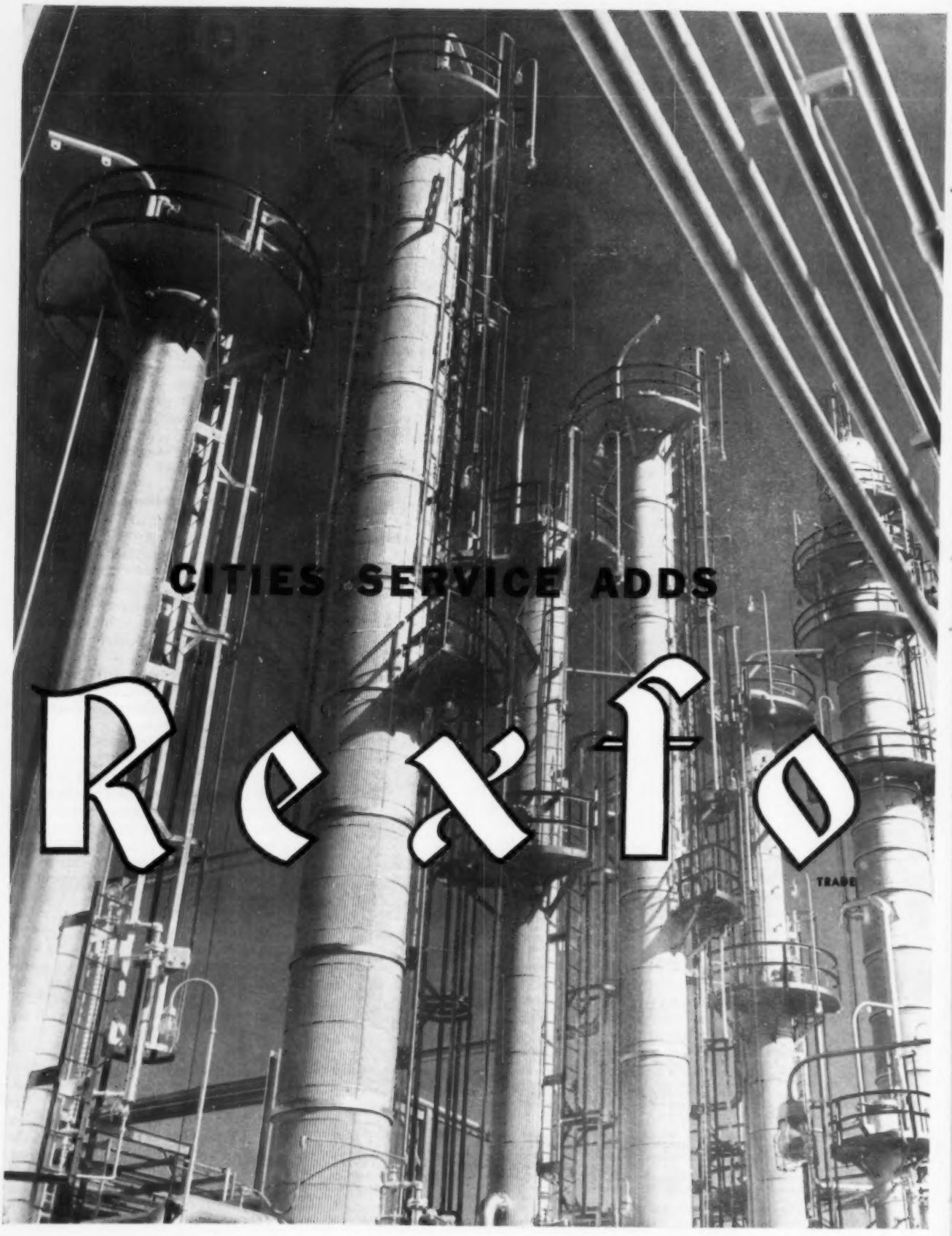
Marketed Production of LP-Gas

Year	Gallons (in thou.)	% Increase	Domestic and motor fuel*	% Increase	Industrial misc.[1]	% Increase	Gas mfg.	% Increase	Chemical mfg.	% Increase	Rubber components	% Increase
1922	223	—	Sale of liquefied petroleum gas confined primarily to bottled gas business prior to 1928									
1923	277	24.4										
1924	376	36.0										
1925	404	7.2										
1926	465	15.2										
1927	1,091	134.6										
1928	4,523	314.6	2,600	—	400	—	1,500	—				
1929	9,931	119.6	5,900	126.9	1,500	275.0	2,500	66.7				
1930	18,017	81.4	11,800	100.0	2,200	46.7	4,000	60.0				
1931	28,770	59.7	15,295	29.6	7,172	226.0	6,303	57.6				
1932	34,115	18.6	16,244	6.2	8,167	13.9	9,703	53.9				
1933	38,931	14.1	16,626	2.3	13,987	71.3	8,318	—14.3				
1934	56,427	44.9	17,681	6.3	32,448	132.0	6,298	—24.3				
1935	76,855	36.2	21,380	20.9	47,894	47.6	7,581	20.4				
1936	106,652	38.8	30,014	40.4	67,267	40.4	9,371	23.6				
1937	141,400	32.6	40,823	36.0	62,610	[2]	11,175	19.3	26,792	—		
1938	165,201	16.8	57,832	41.7	62,694	0.0	12,386	10.8	32,299	20.5		
1939	223,580	35.3	87,530	51.4	93,723	49.4	15,435	24.6	26,892	—16.7		
1940	313,456	40.2	134,018	53.1	124,482	32.8	20,285	31.4	34,671	29.0		
1941	462,852	47.7	220,722	64.7	172,669	68.6	25,255	24.5	44,206	27.5		
1942	585,440	26.5	303,857	37.6	197,179	14.2	31,366	24.2	53,038	20.0		
1943	675,233	15.3	344,962	13.6	237,396	20.4	37,519	19.6	55,356	4.4		
1944	1,060,156	[4]	445,617	29.2	254,590	7.3	45,879	22.3	151,985	175.0	162,085	—
1945	1,276,766	20.4	533,262	19.7	256,577	0.8	53,849	17.4	224,291	47.5	208,787	28.8
1946	1,704,262	33.5	758,466	42.2	253,745	— 1.1	86,660	61.0	311,499	38.8	293,892	40.8
1947	2,209,797	29.7	1,150,538	51.7	274,125	8.0	169,332	95.4	414,267	33.0	201,535	—31.4
1948	2,736,801	23.8	1,473,289	28.1	275,883	0.6	237,638	40.3	524,350	26.6	225,641	11.9
1949	2,836,599	3.6	1,627,350	10.5	247,103	—10.4	239,210	0.6	544,886	3.9	177,850	—21.1
1950	3,482,567	22.8	2,022,464	24.3	355,456	[3]	251,694	5.2	624,468	14.6	228,485	28.5
1951	4,227,275	21.4	2,456,804	21.6	269,408	[3]	281,692	11.9	844,507	35.2	374,864	64.1
1952	4,477,379	5.9	2,636,736	7.4	338,959	26.0	259,697	— 7.8	870,990	3.1	370,997	— 1.1
1953	4,932,009	10.2	2,977,418	12.9	374,233	1.04	222,430	—14.4	967,427	11.1	390,501	5.3
1954	5,125,533	3.9	3,174,012	6.6	401,615	7.3	191,932	—13.7	1,050,239	8.6	307,735	—21.2
1955	6,006,000	17.2	3,661,000	15.3	431,000	7.3	171,000	—10.9	1,262,000	20.2	481,000	56.3

*Household use plus other requirements by these customers such as irrigation pumping, tractor fuel, flame weeding, chicken brooding and similar uses. Included also is LP- as sold by domestic distributors but used for industrial purposes. Included also, in years following 1950, is LP-gas sold direct by producers and marketers solely for fueling internal combustion engines.

(1) For all years prior to 1951, include LP-gas sold for refueling internal combustion engines.
(2) Not comparable due to segregation of chemical manufacturing.
(3) Not comparable due to change in method of reporting LP-gas sold for refueling internal combustion engines.
(4) Not comparable due to inclusion of rubber components.

REMARKS: In this table total sales for all years except 1955 were obtained from U. S. Bureau of Mines reports. Distribution for the years 1931 to 1954 inclusive, was obtained from the same source. All other volumes were estimated by the writers. The total sales volume includes all LP-gas (propane, butane, and propane-butane mixtures) when sold as such. Until 1944 the sale of pentane when sold for any purpose other than motor fuel blending was included. Since then it has been excluded. It does not include butane when blended with heavier petroleum fractions or motor gasoline purposes. Inter-company sales transactions such as purchases of LP-gas by one company from other companies and resold as LP-gas have been eliminated in order to avoid duplication of sales figures.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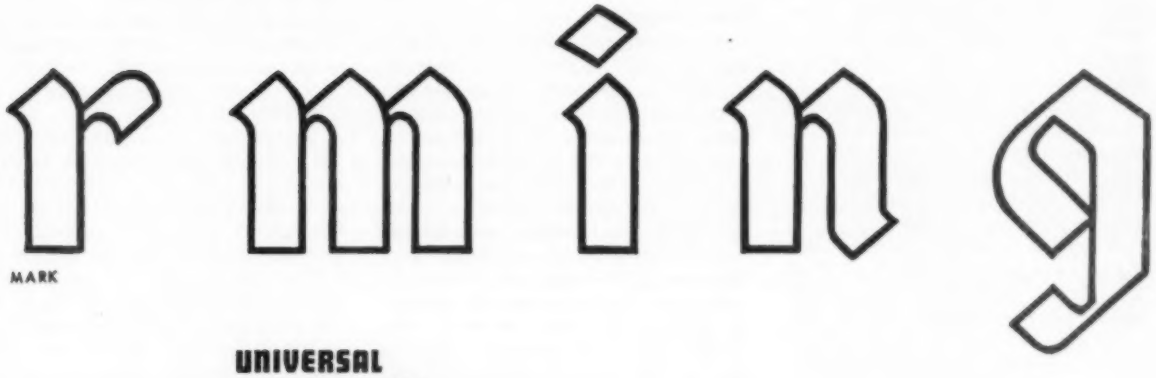
After an exhaustive study, Cities Service Oil Company (Del.) has chosen the UOP Rexforming process as the best method for upgrading low octane naphthas to meet the rapidly increasing demand for higher octane gasolines.

A 6,000 barrel per stream day Rexformer will be installed at Cities Service Ponca City, Okla., refinery as an important part of an extensive new construction and expansion program.

By installing the Rexforming process, the latest development in the catalytic reforming field, Cities Service will be assured of obtaining the best yields of the highest octane blending material for the company's motor fuels. Rexforming, developed by Universal, is capable of producing gasolines having octane ratings considerably in excess of 100 clear.



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In Petroleum Refining Technology

If one were to combine the chemical sales with that which goes into the manufacture of synthetic rubber components (which is really a chemical use), the volume would total 1,743,000,000 or nearly 30 per cent of the entire market.

Rubber

The use of LP-gas in the manufacture of synthetic rubber components jumped 56.3 per cent to a total of 481,000,000 gal. This is the largest single category percentage increase of any of the major markets. It is significant that since the switch to operation by private industry late in April, synthetic rubber production has been at a rate 17 per cent above that of the first four months.

The capacity operation of the industry stems from an unprecedented demand for synthetic rubber and specifically from the largest automobile production ever. It is anticipated that industry will produce nearly 8,000,000 automobiles in 1955. About 6,666,000 were produced in 1950, the largest previous year.

The trend toward tubeless tires as new equipment on most automobiles has resulted in an even greater percentage increase in tire production than is reflected by the gain in automobile production alone. This is caused by the necessity of manufacturers and dealers to carry inventories of both tube and tubeless tires. Other factors include higher prices for natural rubber (over 1954) and increased exports since the synthetic rubber industry was taken over by private industry.

It is believed that the present high rubber demand will continue during the coming year. Private industry has demonstrated a high production capacity and several, including Phillips, have announced major expansions.

A trend is developing in the refining industry toward increased use of butylenes in the production of high octane motor fuel. For numerous refiners, this is the cheapest, and for some the only means of meeting the higher octane requirements of today's automobile engines. A butylene shortage has already developed and will become more critical as octane numbers are pushed higher and higher. Thus, future butadiene manufacture will depend more and more upon normal butane as its raw material.

Supply

The production capacity of the LP-gas industry continues to increase. Twenty-two new plants came on stream in 1955 with a total production capacity of nearly 850,000 gal per day. It is estimated 12 new plants will be added in 1956 with a production capacity approaching a half a million gallons per day. The industry has the potential production capacity to meet large additional demands for LP-gas. An increase in market price would justify the recovery of larger quantities from existing plants.

Storage

Large increases were seen in 1955 in LP-gas storage facilities in both the conventional aboveground steel storage tanks and in underground storage facilities. It is estimated that the LP-gas underground storage capacity presently available totals 602,700,000 gal. There is an additional 292,000,000 gal of underground storage either under construction or proposed. If all of this storage is completed as planned there would be an ultimate total capacity of 894,700,000 gal of underground LP-gas storage. Although most of the underground storage is in salt beds or domes, one cavern in chalk was being completed in 1955 (while one in solid granite was being planned). According to the most recent figures about 400,000,000 gal of LP-gas were in underground storage prior to the heavy withdrawal months in the last quarter.

There was more interest shown in refrigerated storage of LP-gas in 1955 but none definitely announced. Such storage would be in insulated vertical tanks at low temperatures and pressures.

Transportation

Significant additions to the LP-gas transportation facilities were seen in 1955. One new ship (LP-gas tanker) is being readied for Caribbean service. One new ocean-going LP-gas barge was added to the water fleet. Seven products pipelines were announced or under construction which will be equipped for products and LP-gas transportation. It is estimated that there are about 20,000 tank cars in LP-gas service. Because many tank cars are in dual LP-gas and anhydrous ammonia service, the number of LP-gas service during peak demand periods may even exceed this number. Transport truck movements continue to increase. It is estimated that nearly 50 per cent of the LP-gas movement is by transport truck.

Export and Foreign

LP-gas export sales are up about 10 per cent. LP-gas distribution is making rapid strides in Canada, Venezuela, England, France, Italy, Mexico and in the Scandinavian countries. There is at least one LP-gas tanker operating out of Italy, and three tankers operating in the Scandinavian countries, and at least four more LP-gas tankers in service in other ports. There are two butane barges in Holland.

Regulations

LP-gas men have a big stake in the Harris Bill passed last summer by the U. S. House. A companion measure, the Fullbright Bill, is now awaiting action in the Senate. This important legislation would retain for consumers the benefits of competition but lift utility-type federal regulation from gas producing.

Already federal regulation of natural gas producers seems to be decreasing supplies of natural gas, from which nearly 70 per cent of LP-gas is derived. Latest drilling records show a 12 per cent decline in gas well completions in 1955. Also indicating a future decline in production, only 2.3 trillion cubic feet of new gas reserves were committed to large interstate pipelines in 1954, compared with 6.4 trillion in 1953. If this trend is not halted by passage of the Harris Bill, LP-gas dealers will be faced with shorter supplies and higher prices.

The Federal Power Commission has recently said its authority extends back to sales of casinghead gas from each individual well—which is before LP-gas is extracted—if any of the residue gas is destined to move in interstate markets.

And, if federal regulation of gas production is allowed to continue, what will stop it from swallowing up other segments of the petroleum industry—including LP-gas? Thus the life of the LP-gas industry as a free competitive enterprise is endangered.

Outlook

The increase in LP-gas sales for 1955 was the largest in the industry's history. In fact, the sales for 1955 alone far exceeded the total sales for the first 24 years of the industry. Or putting it another way, the amount of LP-gas sold in 1955 far exceeds the total amount of LP-gas sold in all of the years prior to 1946. Competition in the fuel market remains keen and the LP-gas industry must maintain its alertness and initiative if it is to continue to grow.

Complete weather conditioning is just around the corner. This is a "natural" for the gas industry and offers tremendous opportunities for the future growth and for smoothing out the winter-summer ratio. Weather conditioning (winter heating-summer cooling), motor fuel, and house heating applications are the markets offering the greatest sales potential for the LP-gas dealer. LP-gas for chemical purposes will continue to rise significantly.

1956 should be another spectacular growth year for the industry.

P 725.

TECHNOLOGY

Methods for Refining Light Petroleum Distillates and Fuels

V. A. Kalichevsky
Consulting Chemical Engineer

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PETROLEUM fractions prepared by distillation or cracking are treated with chemicals. Some of these chemicals react with certain oil components, others are solvents. The treating methods vary with the type of products manufactured, the nature of crude oil, the procedure used in preparing the fractions and the available treating facilities. The same results can be obtained by employing different treating processes and each refinery has its own procedures for finishing the oils.

Purpose of Chemical Refining

Chemical refining can improve many oil properties but not all of them. Such characteristics as boiling range or vapor pressure can be corrected only by physical means, i.e. by distilling or blending the oil fractions. However, treatment with chemicals can produce stable, non-corrosive materials of light color, good odor and low sulfur content. This can be accomplished in several ways.

The undesirable substances can be removed from the oil by refining with powerful chemicals, like sulfuric acid. This method was used widely in the past but it has several disadvantages. Strong reagents do not possess good selectivity. They remove substances which can be left in the finished product, and do convert them into worthless sludge. For instance, the presence of olefins in gasoline is not objectionable. They have good burning qualities and are stable in storage but are attacked by sulfuric acid. By destroying them the yield of refinery products is reduced and the crude oil is not fully utilized.

Instead of using chemicals, the same "subtractive" refining can be done with solvents. These solvents separate the oil components according to the ease with which they dissolve. All the oil components are recovered in their original state after the solvent is removed and can be employed in the manufacture of petroleum products for which they are best suited. None of the oil is wasted.

Sometimes objectionable properties of an oil can be eliminated by changing the undesirable constituents chemically into substances that can be left in the product. Doctor treatment which is described below, is an example of such treating methods.

The undesirable characteristics of an oil may be improved by adding protective agents for preserving the oxidizable hydrocarbons in storage. The use of these additives in refining gasoline is described elsewhere. They are used even more widely in the heavier petroleum products.

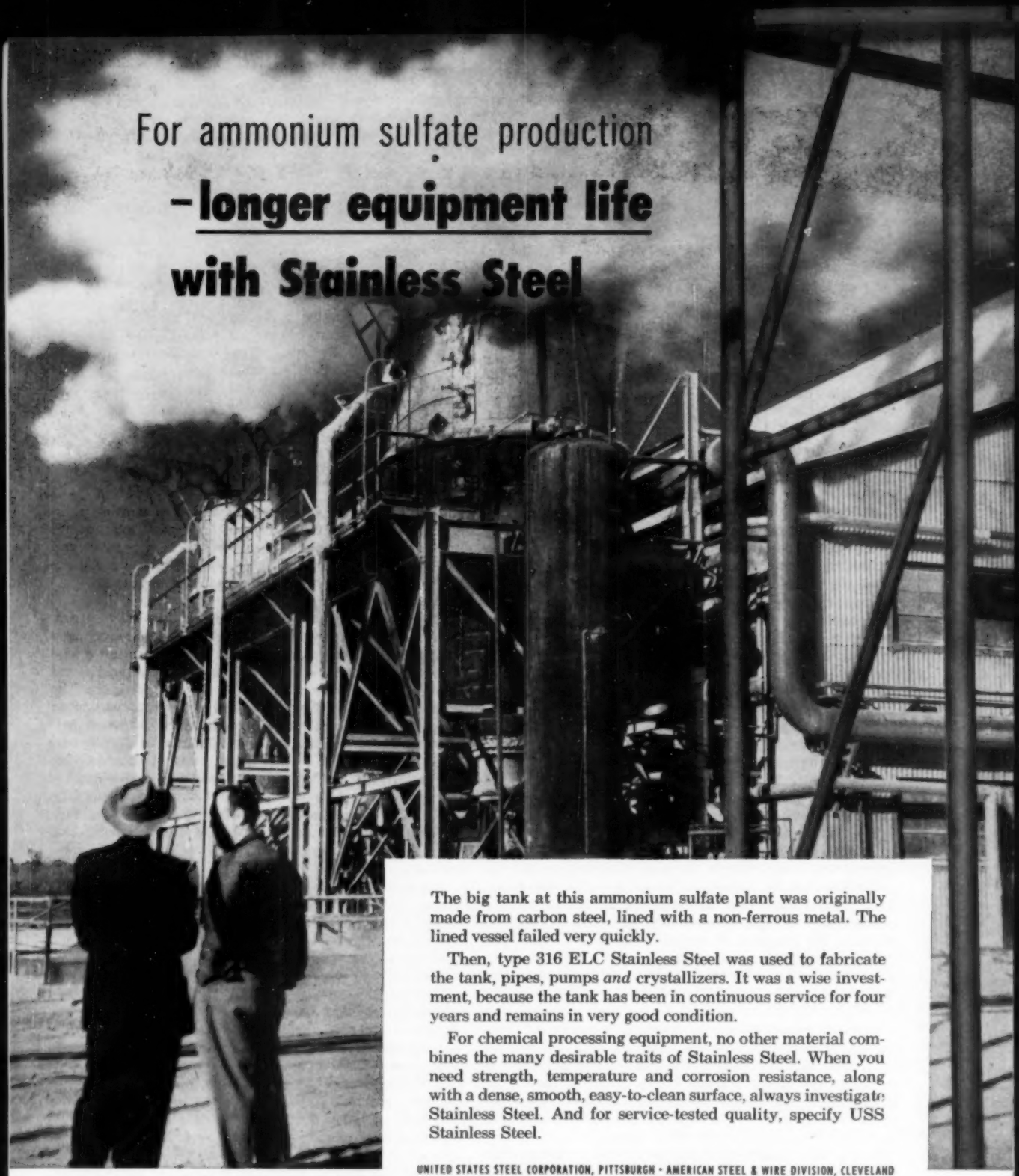
Distillation is not a substitute for chemical refining but good fractionation assists in the solution of treating problems. If fractionation is poor, dark colored substances are carried by the oil vapors into the overhead product and their presence complicates the finishing procedure. All the refinery operations must balance in order to keep the production cost at a minimum.

Chemical terms used around the refineries may be confusing. They are often arbitrary and instead of conveying a proper meaning they might imply whether or not an oil passes a certain test. The significance of chemical terms varies from one unit to another in the same refinery. The so-called "refinery language" is inconsistent even when common words are employed. For instance, the word "tar" is still used although the American Society for Testing Materials suggested for several decades that it should be restricted to coal tar products. In the petroleum industry "tar" may refer to a distillation residuum resembling asphalt or to a distillate of a low boiling range. In the coal-tar industry it has a definite meaning. Local slang around the petroleum refineries must be deciphered before it can be understood.

Chemistry penetrated deeply into the refinery operations and chemical terms must be employed for explaining the workings of many processes. These terms cannot be used at random. The misuse of chemical terms will lead even chemists astray.

Instability of petroleum products is commonly ascribed to the presence of unsaturated hydrocarbons, other than the stable aromatics. These hydrocarbons are divided into diolefins having two double bonds in the molecule and olefins having one double bond. Diolefins are easily oxidized and polymerized; olefins are stable in the absence of diolefins. The presence of olefins is often desirable if the diolefins are absent. The quantity of olefins in petroleum distillates may be large, that of the diolefins seldom exceeds a fraction of one per cent and their removal has no noticeable effect on the product yield. However, diolefins are not the only substances which are responsible for color and gum formation in petroleum distillates. Certain sulfur, oxygen and nitrogen compounds may be the offenders also. The blame for instability of an oil cannot be placed on a single group of hydrocarbons.

Sulfur compounds might be corrosive, but so are some of the oxygen compounds. Sulfur compounds such as mercaptans, have a repulsive odor; the smell of oxygen compounds, such as naphthenic acids, is equally offensive. Asphalt darkens the oil color; polymerized hydrocarbons,



For ammonium sulfate production –longer equipment life with Stainless Steel

Lion Oil Company, Chemical Division, El Dorado, Ark.

The big tank at this ammonium sulfate plant was originally made from carbon steel, lined with a non-ferrous metal. The lined vessel failed very quickly.

Then, type 316 ELC Stainless Steel was used to fabricate the tank, pipes, pumps *and* crystallizers. It was a wise investment, because the tank has been in continuous service for four years and remains in very good condition.

For chemical processing equipment, no other material combines the many desirable traits of Stainless Steel. When you need strength, temperature and corrosion resistance, along with a dense, smooth, easy-to-clean surface, always investigate Stainless Steel. And for service-tested quality, specify USS Stainless Steel.

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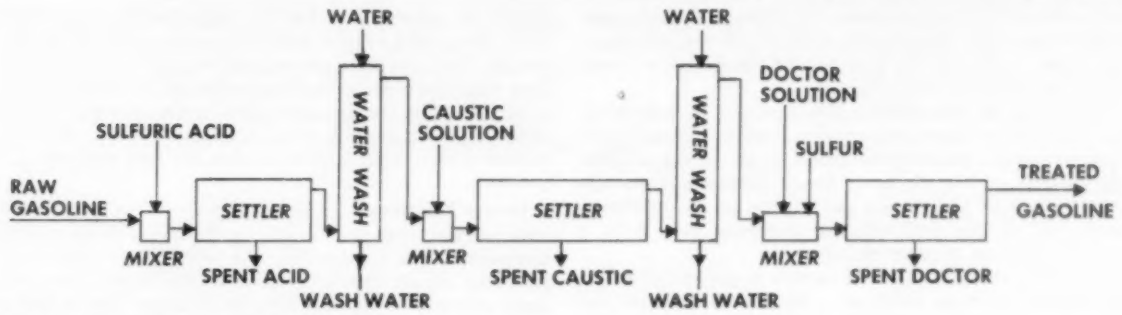

FIG. 1. Conventional gasoline refining process.

nitrogen compounds, even open-chain hydrocarbons may also darken it. The purpose of chemical refining is not the elimination of the oil constituents possessing a certain structure but the production of an oil having good service characteristics.

In applying chemicals to an oil, overtreating may be as harmful as undertreating and in addition is quite expensive. Petroleum oils contain both natural inhibitors and accelerators. The accelerators, like diolefins, speed up the undesirable reactions in an oil and must be eliminated. The inhibitors prevent such reactions from developing and should be left in the oil. If the concentration of inhibitors is reduced below the dangerous limit, they must be added to the oil again, to stabilize the product.

Treating procedures are difficult to classify. Some of them improve more than one oil property and can be used for refining many petroleum products; others are specific in their applications. They are described in relation to the products treated.

Gasoline

Gasoline must contain hydrocarbons that are stable and burn well in the engine. Stability toward oxidation does not mean stability toward chemicals. For instance, olefins are stable in storage, particularly if they are protected with inhibitors, but they react with many chemicals, such as sulfuric acid. This requires caution in selecting the treating processes.

The straight-run gasolines are easy to treat. They contain no unsaturated hydrocarbons. The catalytically cracked gasolines also contain few reactive substances. The thermally cracked gasolines, particularly those produced by the vapor-phase processes, present special problems. Products obtained from the same crude oils or from the same unit and charge stock, but under different operating conditions, may not have the same response to chemicals. The treating conditions must be adjusted accordingly.

The older conventional method for treating gasoline consists in contacting it with sulfuric acid and neutralizing with caustic the traces of acid that are left in it. Gasolines containing mercaptans are sweetened with "doctor solution." A continuous process of this type is shown diagrammatically in Fig. 1. Description of these treating methods gives an insight into the chemistry and applications of the modern treating processes.

Sulfuric Acid Treatment. Sulfuric acid is universal in its action. It attacks a large number of petroleum constituents which means that its selectivity is poor. It is a good decolorizing and deodorizing agent. It "stabilizes" the oil against oxidation and reduces its sulfur content. However, it lowers the octane rating of gasoline and decreases the yield because of the removal of valuable hydrocarbons. For this reason it was largely superseded by other refining methods.

The action of sulfuric acid can be controlled to a certain extent by modifying the treating conditions. These treating conditions are the quantity and strength of the acid used, the treating temperatures and time, and the method of applying the acid to the oil. Within certain limits some of them may compensate for others.

Sulfuric acid attacks an increasingly larger number of oil components when its strength is raised. The refining effect of the acid cannot be increased by using a large quantity of weak acid. However, similar effects are obtained by using small quantities of strong acid instead of large quantities of weak acid if the rest of the treating conditions are adjusted. Acid below 80-85 per cent strength does not attack olefins but reacts with diolefins and may improve the gasoline color and stability. Acid below 93 per cent strength does not attack aromatics. However, a small quantity of the 93 per cent acid properly applied will improve the oil color without having an appreciable effect on the olefins. Variations in the acid activity with the increase in the acid strength are not sharp. Considerable overlaps exist also in the reactivities of hydrocarbons belonging to different series. For instance, some aromatics are attacked before all the olefins are removed.

There are other considerations which control the strength of acid used by the refineries. Sulfuric acid weaker than 80 per cent attacks iron and must be handled in special equipment. Acid of 80 per cent strength melts at +30 F, the 93 per cent acid melts at —26 F, the 98 per cent acid melts at +37 F and the 100 per cent acid melts at +50 F. These variations in melting points are not directly related to the acid strength but they are important to the refineries working under climatic handicaps. Most of the refineries use the 98 per cent acid. Fuming sulfuric acid is seldom employed as it has a very poor selectivity toward various classes of hydrocarbons. It is useful only in the manufacture of specialties.

An increase in treating temperature raises activity of the acid but reduces its selectivity. New hydrocarbons are attacked and sulfuric acid compounds, known as esters, are formed. These compounds may dissolve in appreciable quantities in the treated product and have a harmful effect on its properties. However, at very low temperatures, such as +20 F or +30 F, the acid has a powerful desulfurizing action on some gasolines. These low temperatures are used in the Stratcold acid treating process.

The time of contact is important. Colored substances and unsaturated hydrocarbons react faster with the acid than the aromatics and sulfur compounds. Dark colored substances, however, may form if the time of contact between the acid and the oil is excessive. These substances are difficult to remove. The time of contact must be adjusted depending on the violence of agitation. Sludge must be withdrawn as soon as possible in order to avoid side-reactions producing substances that discolor gasoline and

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reduce its stability. In processes, like those of Sharples and DeLaval, gasoline is mixed thoroughly with the acid for a short time, a fraction of a minute, and the sludge is immediately separated by centrifuging.

This shows that the refinery must establish the best treating conditions for each product manufactured. These conditions should be revised if the crude supply or the processing procedures are changed. Small variations from the adopted routine both in the preparation of the untreated stocks and in the acid treating technique may have a marked effect on product quality.

Gasoline is treated in closed vessels to prevent evaporation of light fractions which are a fire hazard. Gasoline and acid are mixed by feeding them to the same pump, by passing through orifice plates or by using special mixing devices. The process is continuous and the sludge is separated by centrifuging or by settling in large vessels. Gasoline and sludge are withdrawn continuously from the top and bottom of these vessels respectively. Separation must be complete.

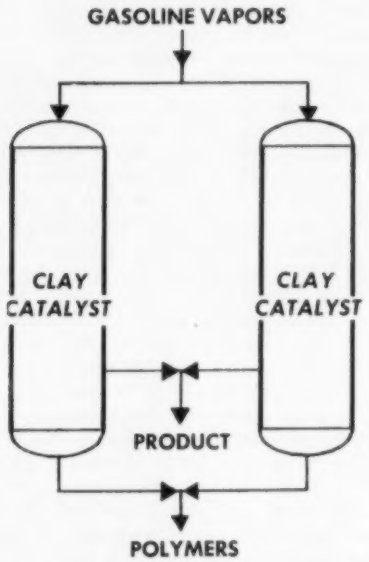


FIG. 2. The Gray clay treating process, used widely during the 1920's and 1930's.

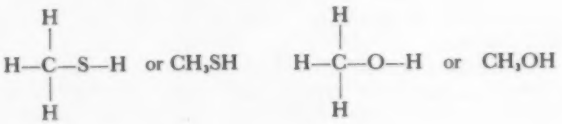
Neutralization with Caustic. The acid treated oils must be treated with caustic solution. This is necessary because the oils containing even traces of acid are unstable. The simplest method for removing the acid is washing the oil with a caustic solution as soon as the sludge is removed.

The strength of the caustic solution used in removing sulfuric acid, which is a strong mineral acid, is of no importance provided the quantity of caustic is sufficient to neutralize all the acid left in the oil. A 10 per cent (14 deg Bé) sodium hydroxide solution is often used. Weak solutions occupy large volumes and strong solutions may form emulsions.

Occasionally the acid treated and neutralized oils are redistilled. These oils contain small quantities of sulfuric acid compounds which decompose if the distillation temperature is above 250-270 F. The distillate must be then washed for the second time with caustic in order to remove the traces of acid they may contain.

Instead of sodium hydroxide, the acid treated gasoline can be neutralized with a finely powdered active clay. The mixture is agitated and the clay separated by using sand filters. Very light colored gasolines can be prepared by this process. Such gasolines are several times more transparent than water. Acid activates the clay which is a better decolorizing agent in the presence than in the absence of acid. However, for preparing stable products, gasoline must be treated with sodium hydroxide after the acid and clay are removed.

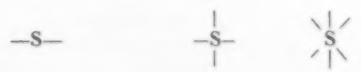
Doctor Treatment. Gasoline, whether or not it is treated with sulfuric acid may contain mercaptans. These sulfur compounds have an offensive odor and their presence is detected by simple chemical reactions. Mercaptans have the same structure as alcohols with the exception that sulfur is substituted for oxygen. For this reason they are called thio-alcohols. The simplest mercaptan is methyl mercaptan and the simplest alcohol is methyl alcohol. They boil at 45.7 F and 148.4 F, respectively.



Methyl mercaptan (45.7 F) — Methyl alcohol (148.4 F)

The —SH group characterizes the mercaptans, same as the —OH group characterizes the alcohols.

The sulfur atom in the mercaptans has two bonds. However, it has four bonds in sulfur dioxide (O = S = O or SO_2) and six bonds in compounds like sulfuric acid. All these compounds are stable.



Two bonds — Four bonds — Six bonds

Sulphur atom

Most sulfur compounds in petroleum have sulfur atoms with two bonds.

The presence of mercaptans is detected by the "doctor test" which is no different from "doctor treatment" with the exception that doctor test is performed in the laboratory and doctor treatment is done in commercial equipment, treating large quantities.

In doctor treatment the "sour" gasoline, i.e. gasoline containing mercaptans, is made "sweet" by reacting with sodium plumbite solution and sulfur. Sodium plumbite is prepared by dissolving litharge, which is lead oxide, in sodium hydroxide solution. The reaction may be visualized as follows:

Mercaptans are very weak acids and they react with lead oxide (PbO) forming lead mercaptides. Thus methyl mercaptan reacts with litharge and forms lead mercaptide.

$$\underset{\text{methyl mercaptan}}{2CH_3SH} + \underset{\text{lead oxide}}{PbO} =$$

$$\underset{\text{lead mercaptide}}{CH_3—S—Pb—S—CH_3} + \underset{\text{water}}{H_2O}$$

Lead mercaptides dissolve in gasoline and change its color to black or brown.

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When sulfur is added, it reacts with lead mercaptide forming lead sulfide (PbS) and methyl disulfide ($(CH_3)_2S_2$). Lead sulfide is insoluble in gasoline and water and forms a "rag" between the two liquids or settles to the bottom of the vessel. The disulfide dissolves in the gasoline but it is colorless. As a result gasoline regains its original color.

$$\underset{\text{lead mercaptide}}{CH_3-S-Pb-S-CH_3} + \underset{\text{sulfur}}{S} =$$
$$\underset{\text{lead sulfide}}{PbS} + \underset{\text{methyl disulfide}}{CH_3-S-S-CH_3}$$

It may be noted that all the sulfur added to the mixture precipitates as lead sulfide if it is used in right quantity. Excess sulfur stays in gasoline solution and if the quantity is greater than three pounds per 1000 bbl the gasoline becomes corrosive. *Addition of sulfur must be done VERY CAUTIOUSLY.*

Lead sulfide is regenerated by blowing with air the spent sodium plumbite solution containing the black precipitate.

$$\underset{\text{lead sulfide}}{PbS} + \underset{\text{oxygen}}{2O_2} = \underset{\text{lead oxide}}{PbO} + \underset{\text{sulfur trioxide}}{SO_3}$$

Blowing is done at temperatures close to the boiling point of water to speed up the reaction which is fairly slow and may require several hours. The spent lead oxide must be free of hydrocarbons which form a film around the lead sulfide particles the air cannot penetrate. Spent sodium plumbite solution contains much caustic and dissolves lead oxide as soon as it formed. The resulting solution is ready for reuse.

Many processes were developed for sweetening gasoline. These processes utilize the same oxidation reactions as those involved in doctor treatment even if their mechanism is slightly different. For instance, gasoline containing mercaptans is contacted with lead sulfide in the presence of a small quantity of air. This combines the treating and the regeneration steps in the doctor treating procedure. Lead oxide and sodium hydroxide may be used as a solid reagent by depositing them on an adsorbent. Settling of doctor solution from the treated gasoline is thus avoided. Such variations are numerous.

Besides doctor solution and sulfur other reagents can be employed for sweetening gasoline. The basic reaction which changes mercaptans to disulfides is simple. It needs only sulfur or oxygen for completion. The rest of the chemicals act as transmitting agents and speed up the conversion of mercaptans. This conversion is represented in its simplest form by the following chemical equation:

$$\underset{\text{methyl mercaptan}}{2CH_3SH} + \underset{\text{sulfur}}{S} =$$
$$\underset{\text{methyl disulfide}}{(CH_3)_2S_2} + \underset{\text{hydrogen sulfide}}{H_2S}$$

or, if oxygen is used:

$$\underset{\text{methyl mercaptan}}{2CH_3SH} + \underset{\text{oxygen}}{O} =$$
$$\underset{\text{methyl disulfide}}{(CH_3)_2S_2} + \underset{\text{water}}{H_2O}$$

Hydrogen sulfide produced by the first reaction is not evolved because it forms at once a compound with lead oxide or caustic.

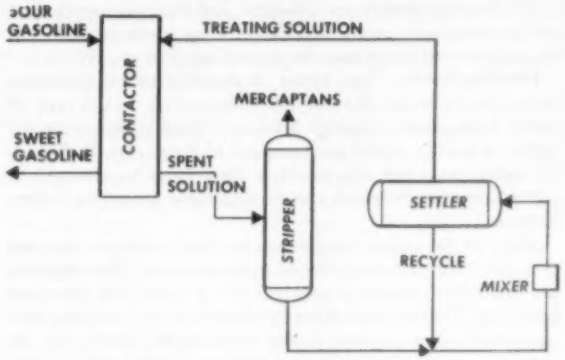

FIG. 3. The Dualayer gasoline treating process.

The sweetening procedures may thus employ sodium or calcium hypochlorite solutions (Hypochlorite process), oxygen and copper chloride slurry (Perco process) and similar reagents. Many petroleum distillates can be sweetened by agitating them with a strong sodium hydroxide solution in the presence of sulfur or by blowing the mixture with air.

Removal of Highly Unstable Hydrocarbons. Drastic treatment for improving color, gum content and oxidation stability of gasoline is not necessary. The highly unstable compounds which have a harmful effect on these gasoline properties can be removed by mild refining. These compounds are easily polymerized forming high boiling molecules that can be separated by distillation. Only a small fraction of gasoline is lost and even this fraction can be utilized as fuel or in the manufacture of by-products. In many of these processes gasoline is treated in the vapor-phase, but liquid-phase processes were also developed.

The first vapor-phase process, known as the Gray clay treating process, was applied successfully to the refining of thermally cracked gasolines. It is shown diagrammatically in Fig. 2. Oil vapors are passed through a bed of fullers' earth where the unstable hydrocarbons are polymerized forming the high boiling compounds or "polymers." Polymers obtained in the Gray process are heavy liquids. They harden in the presence of air and may be used in the manufacture of varnishes. These polymers are different from the polymers obtained in the processes formerly described.

The temperature used in the Gray process is just sufficient to carry the gasoline vapors through the clay bed but not high enough for the polymers to boil. These polymers flow downward and collect at the bottom of the clay bed where they are withdrawn from the unit. The Gray tower is usually connected with the cracking unit and the gasoline vapors pass from one unit to the other before they are condensed. This saves the cost of redistillation.

Instead of clay, other substances can be used for polymerizing the unstable hydrocarbons, i.e. the diolefins. Such substances or their combinations include clay-naphtha slurry (R. K. Stratford process), catalysts used in catalytic cracking processes (Houdry treating process), solutions of zinc chloride and other chemicals (Lachman process), zinc compounds and chlorine (Howard process), and others.

In the liquid-phase processes gasoline is treated with chemicals under pressure to keep it liquid. Chemicals employed are similar to those used in the vapor-phase processes. They may be clay (Osterstrom process), zinc catalyst and hydrogen chloride (UOP treating process), copper chloride and oxygen (Hoover process), and the like.

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All these processes are catalytic and the consumption of chemicals is very small. For instance, as much as 5000 bbl of gasoline and more may be treated per ton of clay.

Desulfurization. Two types of desulfurization problems are encountered by the refineries depending on the type of sulfur compounds present. Some of these compounds are removed easily, others are resistant to chemicals. If the sulfur compounds are non-reactive, they must be changed to sulfur compounds which can be separated from the hydrocarbons.

Most of the sulfur compounds are less stable to heat and catalysts than the majority of hydrocarbons. This explains the low sulfur content of catalytically cracked and reformed gasolines. Thermal gasolines produced at low cracking temperatures often contain sulfur compounds which are resistant to chemicals but the gasolines produced at high temperatures are easier to desulfurize. The straight-run gasolines occupy an intermediate position between the catalytic and thermal gasolines with respect to the ease of desulfurization.

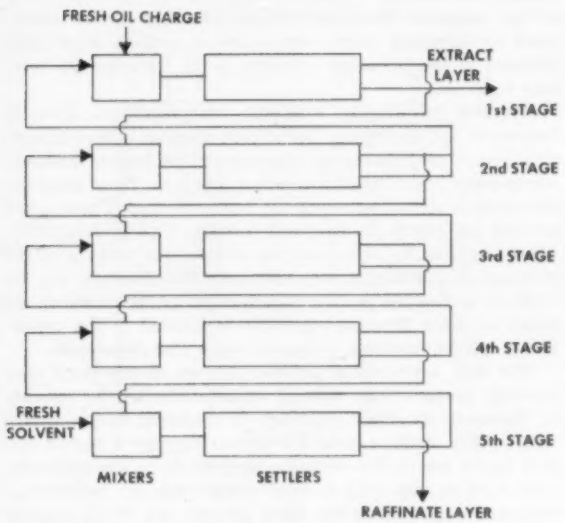


FIG. 4. Liquid sulfur dioxide extraction process.

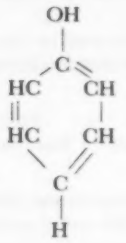
Hydrogenation and catalytic reforming are desulfurization processes although they improve other gasoline properties as well. The strictly desulfurization processes may be compared with these catalytic processes except that the treating conditions are milder in order to affect as little as possible the structure of the desirable hydrocarbons. Gasoline, usually a straight-run product, is vaporized and its vapors are passed through a catalyst bed. Most of the sulfur compounds are converted into hydrogen sulfide which is a gas and also an acid. Hydrogen sulfide is removed from hydrocarbons by distillation or by treating with caustic.

The Gray desulfurization process uses fullers' earth, the same catalyst as that employed in the Gray clay treating process. However, the desulfurization process operates at 700 F and the treating process at 350-400 F. Instead of fullers' earth, bauxite (Perco catalytic desulfurization process) or synthetic catalysts (Houdry catalytic treating process) may be employed.

Many gasolines, including those produced by catalytic cracking, contain considerable quantities of mercaptans. By removing mercaptans from such gasolines the sulfur content is reduced considerably. In the sweetening processes the mercaptans are merely converted into disulfides and the sulfur content remains unchanged.

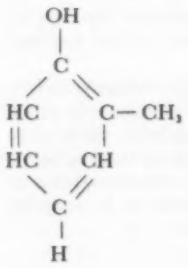
Mercaptans are extremely weak acids and their acidic properties almost disappear when the number of hydrogen and carbon atoms in their molecules is high. Removal of mercaptans from the high boiling petroleum distillates is, therefore, difficult. Very strong sodium hydroxide and, particularly, potassium hydroxide solutions remove a large proportion of the lightest mercaptans but have practically no effect on the high boiling mercaptans. However, the same caustic solutions but containing certain solvents are much more efficient in this respect. The simplest of these solvents are phenols which are present in many gasolines and are available at the refineries.

Phenol is the simplest aromatic alcohol. It contains the —OH group characteristic of alcohols. This group is attached to the benzene ring.

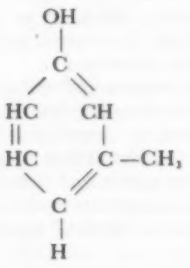


Phenol

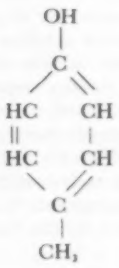
Phenol is a fairly strong acid, known as carbolic acid. Other phenols have the same basic structure but the hydrogen atoms connected to the carbon atoms are substituted by various groups of atoms. These substituted phenols have numerous isomers. The simplest substituted phenols are ortha- meta- and para-cresols. They differ from each other by the relative positions of the —OH and —CH_3 groups in the aromatic ring.



ortho-cresol (boils at 376.7 F)



meta-cresol (boils at 397.0 F)



para-cresol (boils at 396.5 F)

Solutions of these and other phenols in caustic solutions are very efficient for extracting mercaptans from petroleum distillates and are used commercially. While caustic drags out mercaptans by getting hold of the acidic portion of the mercaptan molecule, phenols attract the organic portion thus greatly increasing the solubility effect. Solutizer process, Tannin-Solutizer process, Mercapsol process employ solutions of phenols or related organic substances in caustic for mercaptan removal. In the Unisol process solutions of sodium hydroxide in methyl alcohol and water are used.

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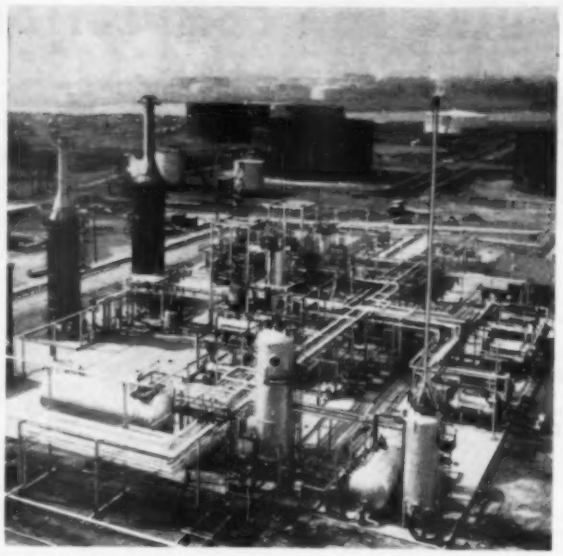

A "pair" of Hydrofiner units installed recently.

When very concentrated sodium hydroxide or potassium hydroxide solutions are saturated with phenols they separate into two layers. The upper layer contains phenols in caustic solution and the lower layer is practically pure caustic solution. The upper layer is an exceptionally good solvent for mercaptans which are completely removed from the gasoline by mixing the two liquids in a simple equipment as shown in Fig. 3. The dissolved mercaptans are removed by blowing the spent reagent with steam or air. The regenerated solution is returned to the extractor and recycled. This process is known as the Dualayer gasoline treating process.

Kerosine

Good kerosine must be free from unsaturated and aromatic hydrocarbons and sulfur compounds. All these substances are attacked by strong sulfuric acid which is an excellent reagent for refining kerosine. For many years kerosines were prepared by using this treating method. It is still used for refining kerosines from crude oils which contain small quantities of aromatic and sulfur compounds. However, aromatics are valuable hydrocarbons and they cannot be recovered from the sulfuric acid sludge. A solvent process, known as the Eedeleanu process, was developed. Solvent dissolves aromatic hydrocarbons in preference to the open-chain hydrocarbons, and the extracted materials are recovered by distilling off the solvent and without changing them chemically.

Kerosine is mixed with the solvent which is liquid sulfur dioxide. Pressure must be applied to prevent sulfur dioxide from evaporating. The mixture is cooled to —10 F or a lower temperature to obtain separation into two layers. The lower layer, or the extract, consists of aromatic hydrocarbons dissolved in the liquid sulfur dioxide; the upper layer, or raffinate, consists of small amounts of sulfur dioxide dissolved in the remaining hydrocarbons.

Efficiency of separation is improved by contacting the oil and the liquid sulfur dioxide counter-currently, as shown in Fig. 4. The fresh oil is first mixed with the partially spent solvent which is rich in aromatic hydrocarbons; the oil leaving the system is mixed with the fresh solvent which has the greatest solubility effect on the aromatics. The treating unit thus consists of several mixers and settlers depending on the number of stages required to obtain a sharp separation between the aromatic and non-aromatic hydrocarbons. Sulfur dioxide is removed from the "extract" and "raffinate" layers by distillation, condensed and returned to the extraction system.

The sulfur dioxide process can be used for improving antiknock qualities of gasolines. In this modification of the process the extract, and not the raffinate phase, contains the desired product because the aromatic hydrocarbons are valuable gasoline compounds. Unfortunately the use of this treating method is not applicable to all gasoline stocks. In addition to the aromatic hydrocarbons, liquid sulfur dioxide dissolves sulfur compounds which are difficult to separate from the aromatics. If the quantity of sulfur compounds is appreciable in the original distillate, they concentrate in the extracted portion and make the product of little value to the refiner.

Solvents

Solvents are refined depending on the service for which they are intended. A caustic wash may be sufficient to prepare a satisfactory product but a small quantity of acid is often used. If the odor of the solvent is important, as in solvents employed in the dry-cleaning establishments, the use of sulfuric acid should be avoided.

In the sulfuric acid treatment reaction products are formed which are known as sulfuric acid esters. These esters, which are compounds of sulfuric acid and hydrocarbons, are formed even when the oil is lightly treated with acid. Although the quantity of esters in the finished product is small, their odor can be detected when the solvent is distilled or evaporated.

Sulfuric acid esters are high boiling compounds. They leave an invisible film on the cloth when the solvent evaporates. The "residual odor," i.e. the odor of the cloth after the solvent evaporates, resembles that of sulfuric acid sludge. Many customers object to this odor and may not accept the solvent prepared by sulfuric acid refining.

Another difficulty with the sulfuric acid esters is that they decompose at temperatures as low as 250-270 F. Solvent containing them will acquire a disagreeable odor of sulfur compounds if it is kept at such temperatures for a long time or if it is distilled. In the dry-cleaning establishments the solvent is recovered by distillation and its odor deteriorates if sulfuric acid esters are present.

Petroleum Fuels

Fuels are cheap and whenever possible they are prepared at the stills without the use of chemicals. However, the distillate fuels which are more expensive than the residual fuels may require chemical treatment. This applies particularly to the fuels obtained from the cracking processes. These fuels are often treated with a small quantity of sulfuric acid or with a strong caustic solution. Occasionally they are redistilled. Refining with a very strong caustic solution is very satisfactory. The Dualayer distillate fuel oil process is used for this purpose. The process is similar to the Dualayer gasoline treating process with the exception that the caustic layer free from organic acids and phenols is employed. The fuel oil thus produced is stable and has an excellent response to inhibitors.

The distillate oils can be also hydrogenated if cheap hydrogen is available. Additives like dicyclopentadienyl-iron, are known which reduce smoking tendencies of these fuels.

Residual fuel oils can be refined with spent sulfuric acid (Goodwin process). The acid removes from the cracked residual oils the highly unstable compounds which form sediment in storage and make the oils incompatible with other oils. However, in most instances satisfactory products are obtained by proper blending of the available refinery stocks.

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REFINERY PLANTS SCHEDULED FOR COMPLETION

A new catalytic reformer is to be built by Continental Oil Company at its Artesia, New Mexico refinery, H. G. Osborn, refining vice president admits. A 1500 bbl-per-day unit licensed by Houdry Process Company will upgrade straight run naphthas to higher octane numbers to compete for motor fuel markets in that area. It will be completed by early 1956.

★ ★ ★

New refinery in Santiago, Cuba will be built by The Texas Company with 20,000-bbl-per-day capacity. It will be the first such plant in Eastern Cuba, and will be complete by early 1957 on a 400-acre site on the west side of the deep water harbor. Plant will cost some $14,000,000 and it's being speeded by the Cuban government, which is trying to interest foreign capital to invest in Cuba.

★ ★ ★

Natural gasoline plant of Continental Oil Company being built north of Casper, Wyoming, will be completed by January 1, the company believes. It will cost $700,-000, process gas from the company's Sussex field, and will process 15,000,000 cu ft per day of raw gas. New unit will add about 10 people to the payroll; and operate in conjunction with the company's $1,750,000 gasoline and repressuring plant, handling gas from three adjacent fields including nearly 250 wells.

★ ★ ★

Delayed coking unit to process 7000 bbl per day of heavy residuum has been placed on stream by D-X Sunray Oil Company at its West Tulsa refinery. Gas oil distillate will be cat cracked to make gasoline and resulting coke will be used as industrial and domestic fuel in the metallurgical industry for electrodes and innumerable other applications. Coke production is expected eventually to reach 240 tons daily.

★ ★ ★

A new catalytic reformer, along with feed preparation facilities is to be built by Ingram Oil & Refining Company at Meraux, Louisiana, by Southwestern Engineering Company of Los Angeles. Unit will be licensed by Universal Oil Products Company, cost about $1,000,000, and have 3000 bbl-per-day capacity. It is due to be completed by about April 1956.

★ ★ ★

Concrete piers capable of docking the world's largest ocean-going tankers, are taking shape on the Delaware River front near the construction site of Tide Water Associated Oil Company's Delaware Flying -A- Refinery, 15 miles south of Wilmington, Delaware. As a site for the new docking facilities, dredges have built up a section of waterfront just north of Delaware City. Pile drivers now are sinking steel shafts to support the concrete decks of the T-head piers. The three finished piers will be equipped so that crude oil cargoes can be pumped at a rate of more than 1,000,000 gal per hour from Tide Water tankers directly to the refinery about a mile and a half inland. Finished products can be piped from the refinery to the piers and into tanker holds. To accommodate these ships, a large turning basin will be dredged in front of the new piers. From this a river channel 40 feet deep and 400 feet wide will extend south over two miles to connect with the river's main channel.

★ ★ ★

A 75,000,000 cu ft gasoline plant will be built by Phillips Petroleum Company in Andrews County, far West Texas. Gasoline Plant Construction Company will build the plant which will serve at least 10 different oil and gas fields in this semi-desert country. It will be the company's 11th plant in West Texas.

★ ★ ★

The first catalytic reformer in Nebraska is being built for the Cooperative Refinery at Scottsbluff, Nebraska. Designed, licensed and engineered by Universal Oil Products Company, it will process 650 bbl per day of low grade naphtha to a leaded octane rating of 95, largely for premium motor fuel.

★ ★ ★

Shell announces latex plant for the first cold high-solids latex—used in making foam rubber—to be manufactured west of the Rockies. It will be produced in new facilities to be built at Shell Chemical Corporation's Torrance, California, synthetic rubber plant. Construction is to start immediately. The plant was not equipped to make cold high-solids latex when Shell Chemical bought it from the government earlier this year.

★ ★ ★

Shell Oil Company's new 55,000 bbl-per-day refinery at Anacortes, Washington, is on stream. Bechtel Corporation turned it over to the company in mid-November. Crude oil is received at the plant from the Trans Mountain Pipe Line Company from Canada's western fields.

American Gilsonite awards contracts to Foster Wheeler Corporation of New York City and Kaiser Engineers of Oakland, California, for the construction of a delayed coking plant and a calcining plant, respectively. Contracts involve total investment in excess of $5,000,000 and are the first to be awarded for the new Gilsonite coke and high-test gasoline plant to be built in the Grand Junction, Colorado, area.

★ ★ ★

West Coast polyethylene plant for Brea Chemicals, Inc., wholly owned subsidiary of Union Oil Company, and Koppers Company of Pittsburgh, is being considered. Location of the new unit has not been announced; however, it has been revealed that the projected unit will have a capacity to produce in the vicinity of 50,000,000 lb of material annually.

★ ★ ★

Considerable expansion of The British Petroleum Company's research station at Sunbury, a few miles from London, England, is being carried out. Latest building to be completed is a laboratory for the testing of motor fuels. Equipment is now being installed and the laboratory will be commissioned early next year. A feature of the new laboratory is the chassis dynamometer room. Here practically any road condition or temperature in the world can be simulated, including wind forces of up to 90 miles an hour, temperatures of 120 F, and a humidity equivalent to that of the Persian Gulf.

★ ★ ★

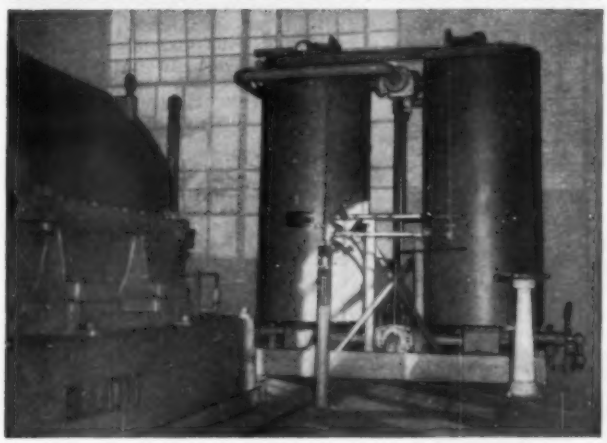
First refinery in Finland will be built by the Lummus Company near Turku, for Neste Oy. Costing $17,000,000, capacity will be 17,000-19,000 bbl per day. Units include a catformer unit of 3400 bbl per day; TC cracker unit of 6000 bbl per day; a catalytic polymerization unit, 500 bbl per day; 1300 bbl per day asphalt and vacuum oxidation unit; an electrical desalting unit, and atmospheric and vacuum oxidation unit.

Dredges like the one above are throwing up a mammoth sand bar along the river front to provide a site for three concrete piers that will serve Tide Water fleet.

DRYing with Lectrodryers

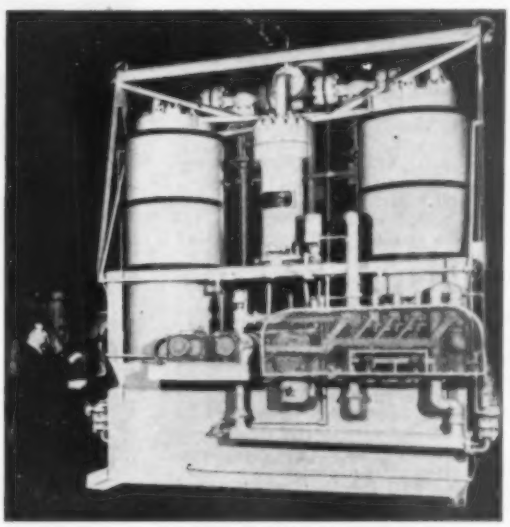
Instrument air controlling a city gas plant

Compressed air in this system controls and records the flow of butane to preheaters, where it vaporizes. The Lectrodryer* keeps that air DRY; no freeze-ups of lines or clogging of delicate instrument ports.



Butane standby for a metropolitan gas system

Manufactured gas used for forcing butane out of the barge tanks in which it arrives at the plant, and again for forcing it into the vaporizing equipment, is dried by this Lectrodryer. Thus, there's no chance of moisture getting into the tanks.



Gases at 5,000 psi. in research work

A package unit, ready to run, but so big it had to be shipped on a depressed-bottom car. Yet this Lectrodryer only needed to be connected to feed lines and it was ready for action. Fully automatic, it reverses the DRYing-regenerating cycle at predetermined intervals.

Whatever your DRYing need—atmospheric or high pressure, small or large volume, manual or automatic control—Lectrodryer can handle the job. For DRYing help, write Pittsburgh Lectrodryer Corporation, 334 32nd St., Pittsburgh 30, Pa.

In England: Birlec, Limited, Tyburn Road, Erdington, Birmingham.
In France: Stein et Roubaix, 24 Rue Erlanger, Paris XVI.
In Belgium: S. A. Belge Stein et Roubaix, 320 Rue du Moulin, Bressoux-Liege.

LECTRODRYERS DRY WITH ACTIVATED ALUMINAS

LECTRODRYER

*REGISTERED TRADEMARK U.S. PAT. OFF.

REFINING AND PETROCHEMICAL

PERSONALS

W. M. Murray has been elected president of the National Lubricating Grease Institute. Chosen as vice president was **J. W. Lane** and as treasurer, **A. J. Daniel.** Murray is vice president of Deep Rock Oil Company, having supervision of bulk sales of refined products, lubricating oils, waxes, napthas, fuels and specialties in domestic and foreign markets. Lane is manager of Socony-Mobil Oil's automotive division, lubricating department. Daniel is president of Battenfeld Grease and Oil Corporation. Directors elected are **D. P. Clark** (Gulf Oil Corporation), **R. Cubicciotti** (L. Sonneborn Sons, Inc.) **H. P. Ferguson** (Standard Oil Company, Ohio), **H. L. Hemmingway** (The Pure Oil Company), **F. R. Hart** (Standard Oil Company, California), **C. L. Johnson** (Jesco Lubricants Company), **George Landis** (Atlantic Refining Company) and **H. A. Mayor Jr.** (Southwest Grease and Oil Company).

Dr. A. D. Suttle has been promoted to senior research chemist for the research and development division at Humble Oil & Refining Company's Baytown, Texas, refinery. He will direct his research efforts to studies in the field of radiation chemistry. Dr. Suttle received his BS in chemistry at Mississippi State College and his PhD in radiochemistry at University of Chicago.

Two Sun Oil Company employees have received the petroleum industry's gold medal award for heroism in saving the life of a fellow employee who had come in contact with a 2300-v line. Representing top recognition by the American Petroleum Institute, the awards were presented to **John R. Viscidy** and **John T. Murphy** by Sun President Robert G. Dunlop. They are the first API Meritorious Safety Awards to be given in the East Coast area. Viscidy and Murphy, both electricians at Sun Oil's Marcus Hook, Pennsylvania, refinery, were credited with quick-thinking heroism in saving the life of a co-worker, **Harry C. Beck.**

Walter Gordon Whitman, conference secretary-general, United Nations International Conference on Peaceful Uses of Atomic Energy and professor and head of the chemical engineering department at Massachusetts Institute of Technology, is the newly elected president of the American Institute of Chemical Engineers. Since 1951 Professor Whitman has been chairman of the Research and Development Board, Department of Defense, and in addition became a member of the National Advisory Committee for Aeronautics.

Robert Lamar Pigford, chairman of the department of chemical engineering, University of Delaware, Newark, Delaware, is the 1955 recipient of the Professional Progress Award in Chemical Engineering, sponsored by the Celanese Corporation of American and administered by the American Institute of Chemical Engineers. The award, which carries with it a prize of $1000, was presented to Professor Pigford at the annual meeting of the institute in November in Detroit, Michigan.

E. A. Malick has been promoted from assistant manager to manager at McGregor, Texas, of the rocket fuels division of Phillips Petroleum Company's research and development department. **P. M. Arnold** has been acting manager of the division in addition to his position as manager of the company's research and development department. Several other management changes were announced in the rocket fuels division of the company, which operates the U. S. Air Force's Plant 66 near McGregor for development and production of rockets. **L. A. Macuila** was promoted to assistant manager of the division. **A. E. Inman** was named manager of management services, **J. F. Sauls** manager of employee relations and **J. E. Dillingham** manager of contracts and finance. **F. M. Files** continues as manager of manufacturing, with **R. J. Martinelli** appointed as assistant manager. A new technical development branch was established, with **E. F. Fiock** as technical director.

E. J. Kirberg

B. R. Dorsey

R. S. Justiss

P. K. Kuhne

E. J. Kirberg, formerly manager of the process division of manufacturing department, has been appointed coordinator for Gulf Oil Corporation. **B. R. Dorsey,** who has been manager of a refinery in Venezuela in which Gulf has a majority interest has been appointed administrative assistant to the vice president. **R. S. Justiss,** formerly manager of the previously designated construction and maintenance division, has been appointed chief engineer of the newly created engineering division. **P. K. Kuhne,** who was assistant manager of the technical division, has been named director of the product division. **Paul Siecke,** formerly assistant manager of the process division, has been designated chief process engineer.

P. Siecke

J. P. Shambaugh

C. F. Ruebensaal

James P. Shambaugh has been named manager of the process promotion division of the manufacturing department of Socony Mobil Oil Company, Inc. He had been assistant manager of the division since 1952 and succeeds **Arthur V. Danner,** who will become a director and vice president of Mobil Overseas Oil Company, Inc., being established January 1. Shambaugh joined the company in 1939 as a chemical engineer in the research and development laboratories at Paulsboro, New Jersey, where he helped develop Socony Mobil's Thermofor Catalytic Cracking process. He received his BS in chemical engineering from the University of Illinois.

Curtis M. Klaerner, manager of the Buffalo, New York, refinery of Socony, has been made assistant general manager of operations for the manufacturing department at the New York City headquarters. He will be succeeded by **T. C. Lockhart,** currently company manager of the light oil operations division of the manufacturing department in New York.

Clayton F. Ruebensaal has been appointed director of commercial planning for the Texas-U. S. Chemical Company, with headquarters in New York. Ruebensaal was formerly manager of commercial development for the Naugatuck Chemical division, United States Rubber Company. Texas-U. S. is equally owned by the rubber company and The Texas Company. He received his chemical engineering degree from Case Institute of Technology.

J. W. Leonard has been elected chairman of the board of directors of the newly formed Leonard Refineries, Inc. Companies that merged recently with Leonard were Mid-West Refineries, Inc., Roosevelt Oil & Refining Corporation and Leondard Pipeline Company. Other officers are **Reid Brazell,** president and chief executive officer; Leonard, chairman of the executive committee; **E. Allan Morrow,** vice president; **L. R. Kamperman,** vice president-marketing; **John S. Pfarr,** vice president-manufacturing; **R. J. Oosdyke,** vice president, Mid-West division; **R. L. Anthony,** secretary-treasurer and controller. **I. C. Gephart** and **Frank Horgan** were appointed as assistant treasurers, with **Harold Richards** and **Wallace Parker** as assistant secretaries, and **William Hertler,** Horgan and **Earl Warner** selected as assistant controllers.

Edgar L. Piret, professor of chemical engineering at the University of Minnesota, received the William H. Walker Award of the American Institute of Chemical Engineers. The award, honoring the memory of the late William H. Walker, a professor at the Massachusetts Institute of Technology was presented during the annual meeting of the institute in November in Detroit, Michigan.

▸ **H. V. Flemming Jr.** has been advanced to vice president in charge of sales, and **P. H. Smith** to vice president in charge of construction for Refinery Engineering of Tulsa, Oklahoma. Flemming joined Treco in 1948 in the purchasing department and in 1953 was made manager of sales. Smith came to Treco in 1947 and for the past year has served as chief estimator. The Treco organization has announced six other personnel changes. Employees and their new positions are **D. F. Ferguson,** process development engineer; **A. C. Frederick,** chief process engineer; **D. B. Crawford,** chief estimator; **W. L. White, D. R. Turner** and **L. D. Travis**, project engineers.

▸ **L. T. Wilson** has been appointed manager of the Montreal East refinery of Shell Oil Company of Canada, Ltd. Wilson comes to his new post from Shell's Norco, Louisiana, refinery where he was superintendent. He began work with Shell in 1933 as a junior inspector at the company's Wilmington, California, refinery.

▸ **William A. Ladd,** pioneer in electron microscopy, has become associated with Foster D. Snell, Inc., consulting chemists and engineers.

Ladd was with Columbian Carbon Company for 15 years, where he led in using the electron beam to picture and measure the extremely fine particles of carbon black.

▸ **Horace H. Chandler** has been named superintendent of Texaco's Eagle Point Works at Westville, New Jersey. Chandler had been assistant superintendent there since 1954. He succeeds **R. H. Aitken,** who has been appointed manager of the refining division of Texaco's foreign operations department (Western Hemisphere and West Africa). **W. R. Sorenson,** assistant supervisor of the process division in New York City, has been made assistant superintendent of the Eagle Point Works. Chandler was graduated with a degree in mechanical engineering from Cornell University. He joined The Texas Company in 1932 as a student trainee at the Port Arthur, Texas, works. Sorenson is a graduate of Kansas University, where he received a BS in chemical engineering. He joined Texaco in 1937 at the Port Arthur Works.

▸ **T. E. Peterson** has been promoted to general foreman of the distillation department at the Baytown, Texas, refinery of Humble Oil & Refining Company. He will be in charge of all crude distillation as well as certain re-run operations at Baytown. He holds a BS degree in chemical engineering from Texas A&M College.

▸ **Torald Mundal** has been appointed vice president and chief engineer of the International Engineering Company, Inc., a subsidiary of Morrison-Knudsen. Mundal joined International Engineering in 1948 as chief design engineer with a background of engineering dams and power plants in the U. S., Canada and South America. He has helped supervise planning for many of the company's diversified projects around the globe, including India's Hirakud Dam, the Alcan Project in Canada and development of San Francisco Bay in California. A native of Balestrand, Norway, Mundal attended Norway's Volda College and was graduated from the Polytechnic Institute at Trondheim with a civil engineering degree.

▸ **C. M. Floyd** has been promoted to senior research chemical engineer at the research and development division of Humble's Baytown refinery. He will be engaged in field test work in which the performance of lubricants in various applications are studied. Floyd received a BS in chemical engineering at the University of Texas. **Harry E. Cier** has been advanced to research specialist of the division at Humble's Baytown refinery. He received a BS in chemical engineering at Louisiana State University. **G. R. L. Shepherd** has been promoted section head of the division at the Baytown refinery. He will head the section responsible for research in the fields of alkylation, polymerization, hydrogenation, hydro-cracking, isomerization, photochemical reactions and other related processes. He holds a BS and MS in chemical engineering from Georgia Institute of Technology.

▸ **Leroy Page** of Paducah, Kentucky, has been awarded the $2000 Phillips Petroleum Company fellowship in chemical engineering at the University of Oklahoma. Page will receive $1500 of that amount, and the other $500 will be available for special project expenses. Before enrolling at OU, Page attended the University of Arkansas and received a BS in geology in 1951. At OU he received a BS in chemical engineering last spring.

Last summer he worked in Phillip's research department. He also has worked for the Atlantic Refining Company as a reservoir engineer.

▸ Several appointments have been made to staff the new plastics sales division of Phillips Chemical Company, wholly owned subsidiary of Phillips Petroleum Company. All men selected to fill the new positions are Phillips employees experienced either directly in the plastics field or in work qualifying them for their new appointments. **W. C. Douce, J. T. Roach, R. G. Askew** and **C. R. Scott** have been named district managers for plastics sales division offices to be established next spring in New York City, Chicago, Illinois, Los Angeles, California, and Boston, Massachusetts. **W. R. Barrett** and **G. F. Blinzler** will become sales engineers for the Boston and Chicago district offices. **M. W. Davidson** has been named supervisor of the sales service and development branch of the plastic sales division's Bartlesville, Oklahoma, office, and **L. B. Croley, J. V. Smith** and **A. L. Walters** will become sales service engineers in that branch. Until the new district offices are established, the district managers and sales engineers will operate from the company's Bartlesville headquarters.

▸ **Dr. Alex G. Oblad,** manager of research and development of the Houdry Process Corporation, Marcus Hook, Pennsylvania, has been elected chairman of the American Chemical Society's division of petroleum chemistry for 1955-56. He succeeds **Dr. Everett C. Hughes,** chief of the chemical and physical research division of the Standard Oil Company of Ohio, Cleveland, Ohio. **Dr. Sherman S. Shaffer,** staff associate in the refining, technical and research divisions of Humble Oil and Refining Company, Baytown, Texas, has been named chairman-elect, and **Wheeler G. Lovell,** director of automotive products developing in the Ethyl Corporation, Detroit, Michigan, has been re-elected secretary-treasurer.

Chosen to represent the division's six geographical areas on the division executive committee were: **John S. Ball,** United States Bureau of Mines, Laramie, Wyoming; **Dr. Philip C. White,** Pan American Refining Corporation, Texas City, Texas; **Dr. Robert F. Marschner,** Standard Oil Company of Indiana, Whiting, Indiana; **Dr. Leslie C. Beard Jr.,** Socony Mobil Oil Company, Inc., New York City; **Dr. John W. Brooks,** Socony Mobil's plant, Paulsboro, New Jersey, and **Dr. Jerry McAfee,** Gulf Research & Development Company, Pittsburgh, Pennsylvania.

▸ **D. J. Stark,** who was recently named plant manager for Escambia Bay Chemical Corporation, has assumed his new duties at Pensacola, Florida, where the company has a multi-million dollar petrochemical plant under construction.

▸ **Rex Duhon** of Lafayette, Louisiana, has won the $2500 Sinclair Refining Company fellowship in petroleum engineering at the University of Oklahoma for the 1955-56 school year. Duhon will receive $1500 for living expenses and $1000 for special project expenses.

▸ **D. R. Beasley** has been transferred from the plant at Institute, West Virginia, to the fine chemicals sales group to work on the market development of coal chemicals for Carbide and Carbon Chemicals Company, a division of Union Carbide and Carbon Corporation. **Mrs. Mary Anna Bresnahan** has joined the fine chemicals sales group to work on industry studies and to assist with various market development proprams. **J. D. Mueller,** after training at Boyce Thompson Institute for Plant Research, will be assigned to the sales group for Crag agricultural chemicals. **Arvid Teleki** has joined the market research department to work on industrial economic research.

The following assignments of technical representatives have also been made recently. **A. P. Chavent,** to the Cincinnati, Ohio, district; **A. A. Douglas,** Charlotte, West Virginia, district; **W. P. Emerson,** Atlanta, Georgia, district; **J. F. Flynn,** Boston, Massachusetts, district; **J. T. Fox,** New Orleans, Louisiana, district; **R. F. Gildehaus Jr.,** Philadelphia, Pennsylvania, district; **D. P. Shannon,** Kansas City, Missouri, district; **B. H. Wilder,** Detroit, Michigan, district, and **R. W. Wittmus,** Indianapolis, Indiana, district.

New Catalysts Series

A new series of cracking catalysts with superior resistance to metallic poisoning is now in production by The Filtrol Corporation of Los Angeles, California. This series is characterized by a very high alumina content.

The catalyst can be tailored to refiners' specific requirements and is available with alumina contents ranging up to 90 per cent. It is offered in the form of closely sized microspheres for fluid cracking and high-hardness pellets for all types of moving bed processes.

This moderately priced catalyst produces extra high yields of gasoline and distillate fuel at lower coke production. These performance records were obtained on full-scale and pilot-plant runs. The high liquid yield plus low catalyst loss offer many economic advantages to the petroleum refiner.

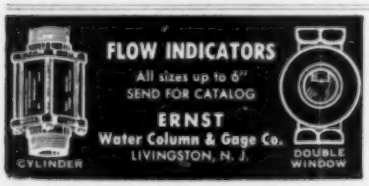
Personals

William E. Ranz, associate professor in engineering research, at Pennsylvania State University, was named winner of the 1955 Junior Award in chemical engineering granted by the American Institute of Chemical Engineers. Outstanding contributions to the literature of chemical engineering were the basis for this award.

Howard E. Hughes has been promoted to the position of superintendent of Shell Chemical Corporation's Houston, Texas, plant.

He has been serving as technical assistant superintendent since 1954 and replaces **Frank G. Watson,** who has been named assistant to the vice president of manufacturing in the company's head office in New York City. A graduate of the University of California, Hughes joined Shell Chemical as a tester at the Martinez, California, plant in 1934.

William B. Borst has been appointed co-ordinator of construction and refining by Ashland Oil & Refining Company. He has been superintendent of Ashland refinery at Canton, Ohio, since 1947. He has been at that plant since 1936, when he started as a chemist with the Alco Refining Company before the plant was taken over by Allied Oil Company, now an Ashland Oil subsidiary.



R. S. Douglass has been appointed superintendent of the Shell refinery at Norco, Louisiana. Douglass succeeds **L. T. Wilson,** who has been named manager of the Montreal refinery at Shell Oil Company of Canada, Ltd. For the past nine years, Douglass has been assistant manager of the manufacturing engineering department in Shell's head office in New York City. A graduate of the Missouri School of Mines with a degree in mechanical engineering, he joined Shell at the Wood River refinery in 1927.

Dr. B. R. Banerjee has been advanced in standard Oil Company's engineering research department in Whiting, Indiana, to group leader of the diffraction group in the physical metallurgy section, materials division. He joined the company's engineering research department at Whiting in 1951 as a research engineer and has been an assistant project engineer since 1953. A native of Calcutta, India, he is a graduate in metallurgy of the University of Calcutta and also took his master's and doctor's degrees in this field at Yale University.

Dilmas V. Fitz, formerly assistant general superintendent, has been named general superintendent of the Petro-Tex Chemical Corporation. **H. A. Harrison** has been promoted to production superintendent from process superintendent. He will also perform the duties of assistant general superintendent. Replacing Harrison is **C. Herbert Sloan,** promoted from administrative assistant. **Walter A. Myrick III,** formerly senior chemical engineer, is the new administrative assistant. All four men are longtime employees at the plant.

C. E. Davis, Shell Oil Company vice president in charge of refining since 1949, has retired after 38 years with the firm. He will become a petroleum consultant and serve part time as general secretary of the Fifth World Petroleum Congress, which will convene in the United States in 1959. He is now chairman of the refining panel of the Military Petroleum Advisory Board.

In other changes effective January 1 in Shell's manufacturing department, **R. W. McOmie,** manager of the Anacortes, Washington, refinery, will become general manager of refineries, and **L. R. Goldsmith,** manager of manufacturing, will become general manager of technical departments. McOmie will be succeeded as manager at Anacortes by **R. C. Barton,** who is now superintendent of the refinery. McOmie, a graduate of Stanford University, joined Shell in 1927 as a chemist at the Martinez, California, refinery. Barton joined Shell in 1934 as a chemist. He will be succeeded as Anacortes refinery superintendent by **J. B. Wyman,** now assistant manager of Shell's New York manufacturing operations department.

Dr. George F. Kirby, who joined Ethyl Corporation as a chemist 15 years ago, has been elected vice president in charge of research and engineering. In this post, he succeeds **B. Bynum Turner,** who has been elected executive vice president, a new position. **Francis J. Sergeys,** director of the chemical engineering division, has been promoted to general manager of research and engineering operations at Baton Rouge, Louisiana, and Houston, Texas, to succeed Dr. Kirby. **Dr. Paul A. McKim,** assistant director of process development, has been named to succeed Sergeys.

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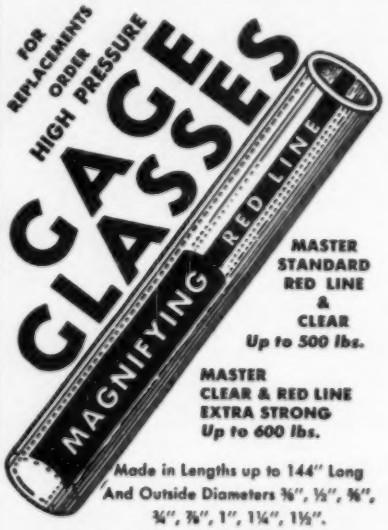
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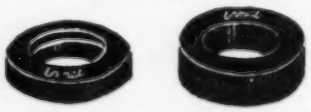

FIG. 21—Lip Mold FIG. 22—Standard

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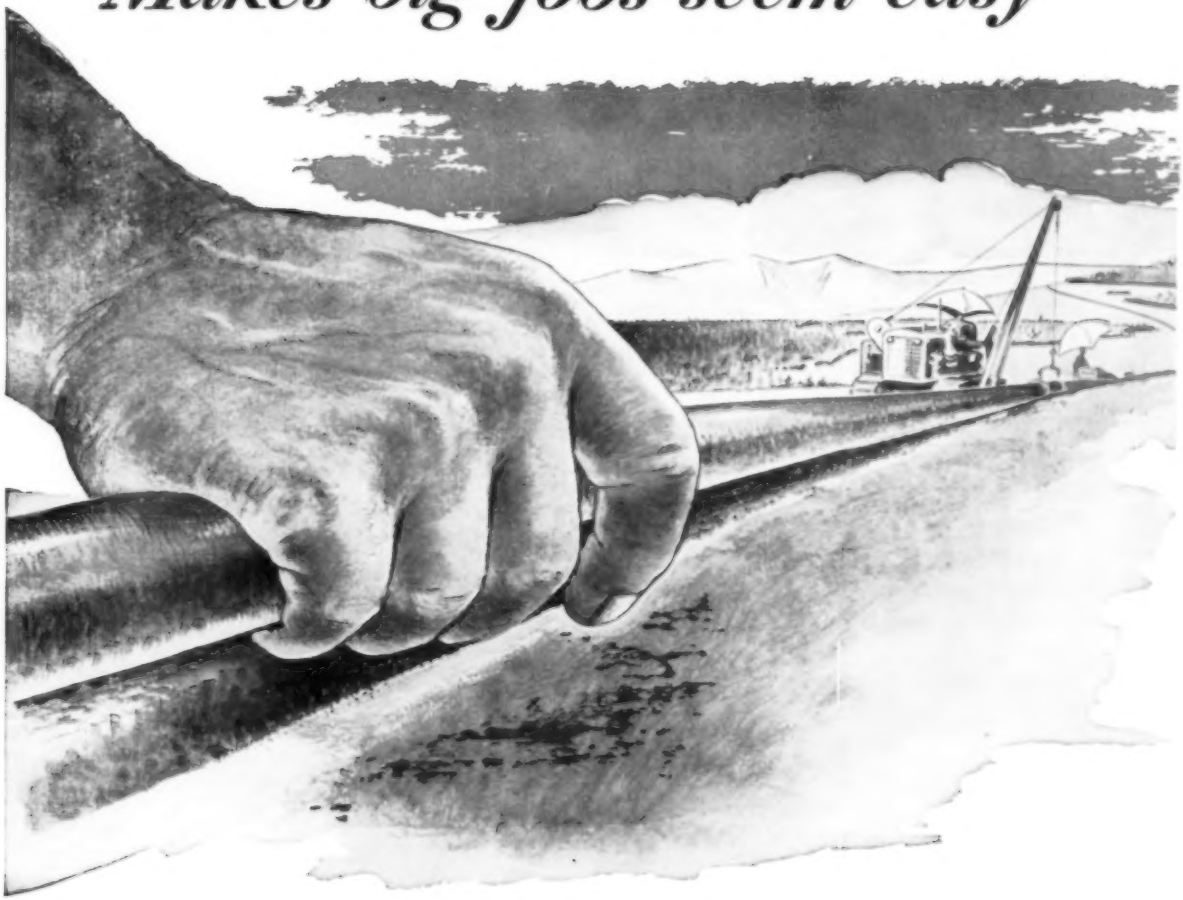

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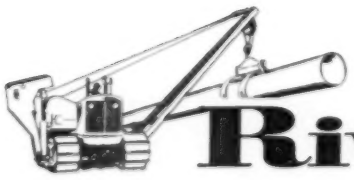

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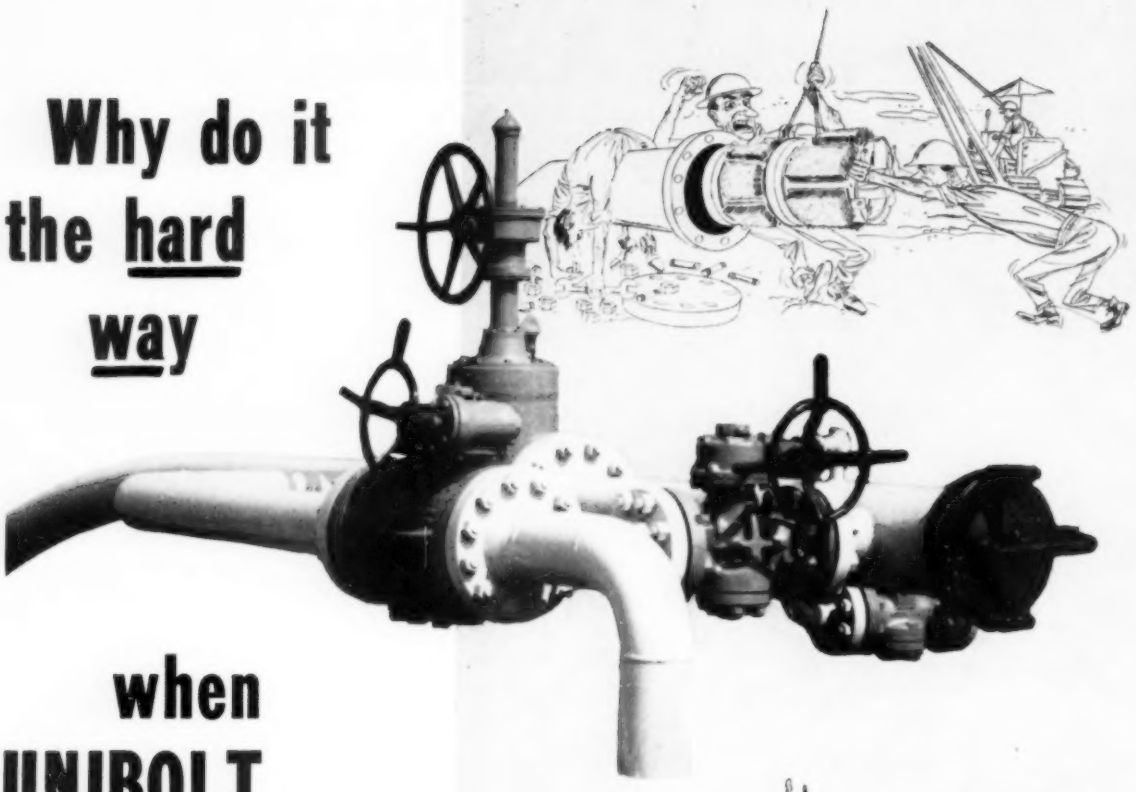
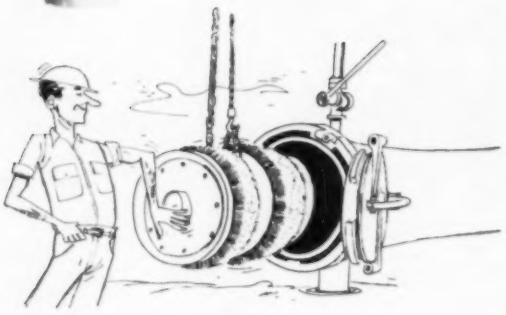


when UNIBOLT Scraper Traps

(with oversize barrel)

make pigging so easy!



Unibolt Scraper Trap Closures are the most convenient, most practical means for blanking off a line so that pigs may be easily inserted and removed from the trap. The scraper barrel being slightly larger than the pipe itself, the pig is easily inserted or removed. It is no longer necessary to "fight" the pig in and out of the trap. Release two bolts and the blanking plug swings open on a sturdy hinge. Swing the trap shut, tighten the bolts, and that's all. Let the pumps do the hard work. No heavy blind flanges to lift on or off. No multiple bolts to release and make up. Nothing to fall on the workmen. No leaky threads. An oil-resistant gasket seals automatically . . . seldom needs replacing.

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PIPE LINE DEVELOPMENTS ★ ★ ★

Roundup of Current Planned and Proposed Construction

The following tables list the company, mileage, pipe size, and location of proposed pipe line projects — crude, products, and natural gas — reported to The Petroleum Engineer. Company addresses are given where furnished or known.

Name of Company	Miles	Size	Location
Ar-Mex Pipeline Company, Dallas, Texas	790	12–14	Guernsey, Wyoming to Coolidge, Arizona
Big Horn Pipe Line Company, Cheyenne, Wyoming	150	8	Ash Creek field to Service Pipe Line Company connection
Kaybee Pipe Line Company, Muskegon, Michigan	46	10	Griffith, Indiana to New Buffalo, Michigan
Michi, Inc., Detroit, Michigan	222	10	Highland Indiana to Alma, Michigan
National Co-Operative Refinery Association, Kansas City, Missouri	30	8	Lyons to Mc Pherson, Kansas
Offshore Gathering Company, Houston, Texas	364	20	Offshore line in Gulf of Mexico from Sabine Pass to Mississippi River.
Powder River Pipe Line Company, Casper Wyoming	436	10–16	Williston Basin to Laurel-Billings, Montana, refining area
Richfield Oil Corporation, Los Angeles, California	4	10	Lines in Los Angeles area
Sinclair Pipe Line Company, Independence, Kansas	150	20	Mexia to Houston, Texas. Replacement of existing line.
Stanmount Pipe Line Company	140	10	Beaver Lake field, North Dakota to Cromer, Manitoba station on Interprovincial Pipe Line
Trans-Border Pipe Line Company	110	—	Skagway, Alaska to Whitehorse, Yukon Territory
Trans-Prairie Pipe Lines, Ltd., Winnipeg, Manitoba	17	3–6	Lines in Cromer and Virden areas, Manitoba
Union Oil Company, Los Angeles, California	815	—	Considering line from shale oil plant at Rifle, Colorado, to Los Angeles area
U. S. Department of Defense	97	—	Crude line from Elk Hills Naval Reserve to Los Angeles

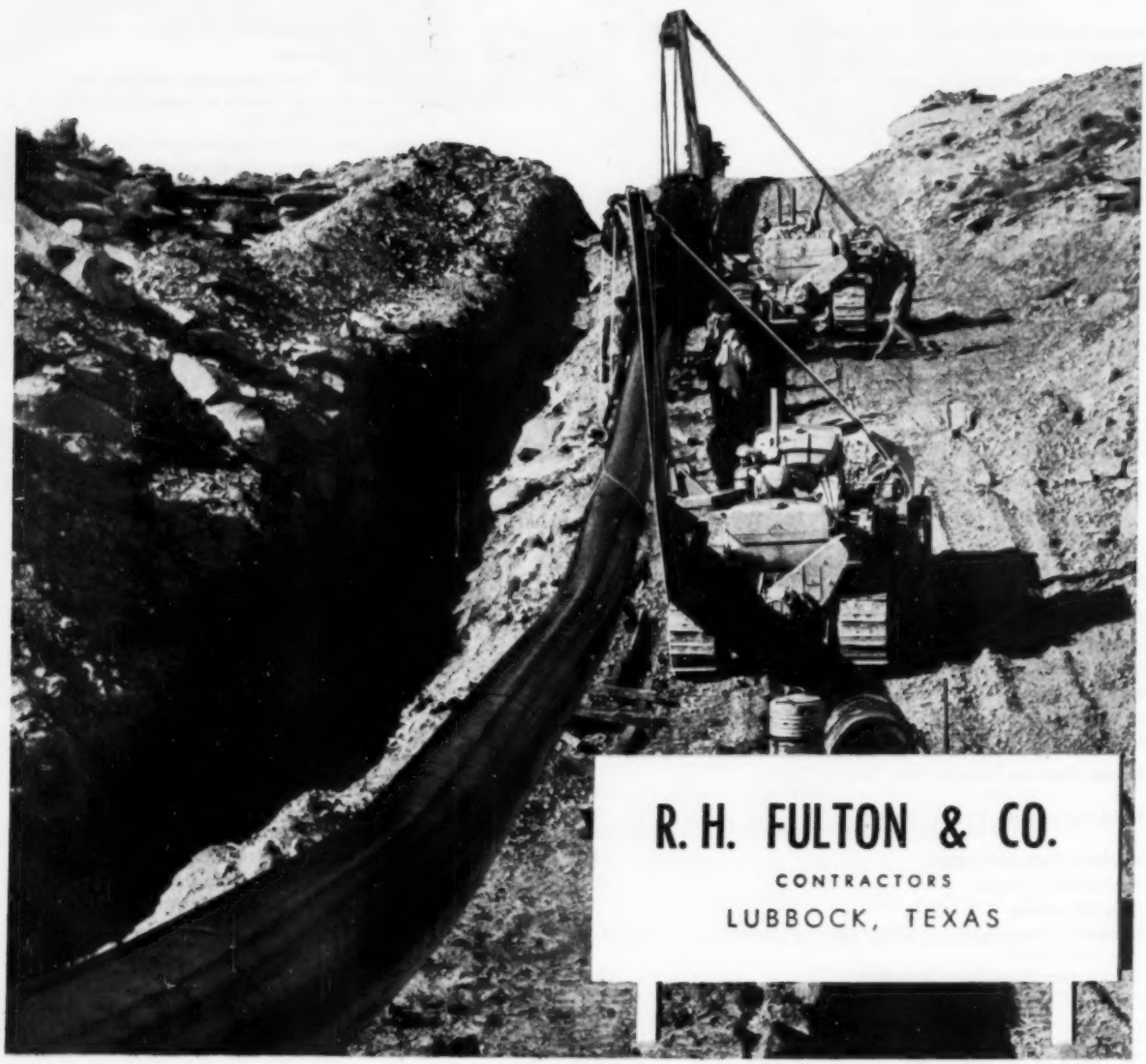
PRODUCTS LINES

Name of Company	Miles	Size	Location
Ar-Mex Pipe Line Company, Dallas, Texas	60	8	Coolidge to Phoenix, Arizona
	70	8	Coolidge to Tuscon, Arizona
Bell Oil and Gas Company, Tulsa, Oklahoma	140	6–8	Ardmore to Cushing, Oklahoma
California-Oregon Pipe Line System, Crescent City, California	103	6	Crescent City, California to Medford, Oregon
Cosden Petroleum Corporation, Big Spring, Texas	100	6	Big Spring, to Abilene, Texas
Deep Rock Gas Company (LPG Line)	120	6	Tioga, North Dakota to U.S.-Canadian Border
El Paso Natural Gas Company, El Paso, Texas (LPG Line)	60	10	Farmington to Gallup, New Mexico
International Pipe Line, Inc., Minneapolis, Minnesota	132	8	Wrenshall to Minneapolis, Minnesota
Magnolia Pipe Line Company, Dallas, Texas (LPG Line)	214	8	Midland to DeLeon, Texas (Converting existing crude line)
(LPG Line)	240	10	Corsicana to Beaumont, Texas (Converting existing crude line)
Maloo Pipe Line, Inc., Roswell, New Mexico	91	6	Prewitt to Albuquerque, New Mexico
	138	6	Artesia to Newman, New Mexico
Mayflower Pipe Line Company	400	10	New Jersey refineries to New England points
Moore-Stoner Company	200	6	Glendive, Montana to Minot, North Dakota
Sioux Oil Company	50	6	Newcastle, Wyoming to Rapid City, South Dakota
Standard Oil Company (Ohio) c/o Sohio Pipe Line Company, St. Louis, Missouri	35.5	6	Mogadore to Girad, Ohio
Texas Eastern Transmission Corporation, Shreveport, Louisiana	1168	16–20	Plans to convert the "Little Inch" line between Beaumont, Texas and Moundsville, West Virginia upon completion of new gas facilities. Has FPC approval to abandon gas service from the "Little Inch."
Winnipeg & Central Gas Company, Winnipeg, Manitoba (LPG Line)	210	6	U.S.-Canadian border to Winnipeg (See also Deep Rock Gas Company listing)

PIPELINES

. . . IN THE UNITED STATES AND CANADA!

OIL LINES
WATER PIPELINES
RIVER CROSSINGS
PRODUCTS PIPELINES
GAS PIPELINE CONSTRUCTION



R. H. FULTON & CO.

CONTRACTORS

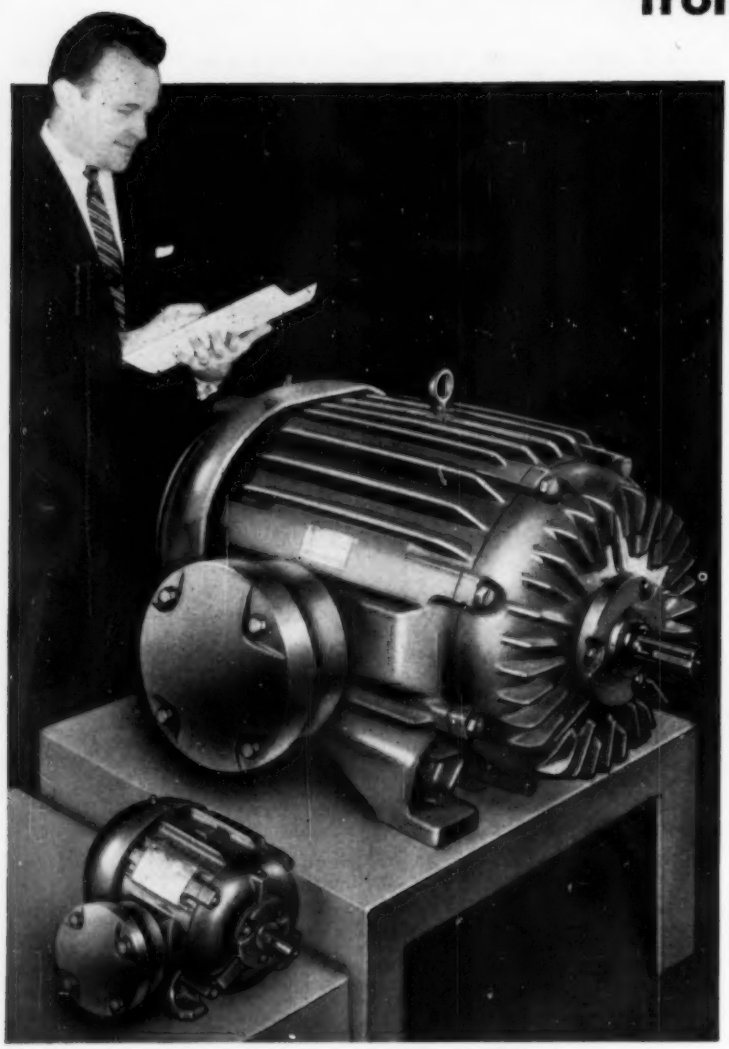
LUBBOCK, TEXAS

GAS LINES

Name of Company	Miles	Size	Location
Alberta Gas Trunkline, Calgary, Alberta	315	6–34	Gas gathering system in Alberta fields to serve proposed Trans Canada Pipe Lines
American Louisiana Pipe Line Company, Detroit, Michigan	117	22	Defiance, Ohio, to Bridgman, Michigan
Arkansas-Louisiana Gas Company, Shreveport, Louisiana	76	24	Loops in Louisiana
Carolina Natural Gas Corporation	185	2–12	Lines in North and South Carolinas
Central Hudson Gas & Electric Corporation, Albany, New York	48	12	Albany to Kingston, New York
Central Kentucky Natural Gas Company, Charleston, West Virginia	21.1	20–24	New lines in Kentucky
Coastal Transmission Corporation, Dallas, Texas	550	30	McAllen, Texas to Baton Rouge, Louisiana
Colorado Interstate Gas Company, Colorado Springs, Colorado	110	6–8	Julesburg area to Denver, Colorado
El Paso Natural Gas Company, El Paso, Texas	413	34	Farmington, New Mexico to Topock, Arizona
Houston Texas Gas & Oil Company, Houston, Texas	961	12–20	Baton Rouge, Louisiana to Miami, Florida, serving Florida area with various laterals
Lone Star Gas Company, Dallas, Texas	230	30	Cotton County, Oklahoma to Fritch, Texas
	205	24	Snyder, Texas to Cotton-Fritch line
Michigan-Wisconsin Pipe Line, Detroit, Michigan	252	4–24	Loops on system in Missouri, Iowa, Illinois, and Wisconsin
Michigan-Consolidated Gas Company, Detroit, Michigan	25	12	Sparta to Muskegon, Michigan
Midwestern Gas Transmission Company, Houston, Texas	1112	12–24	Main line from US-Canadian Border near Emerson, Manitoba-Noyes, Minnesota to Portland, Tennessee
	648	3–18	Laterals off main line to serve communities in Minnesota, North Dakota, and Wisconsin
Mid-Western Industrial Pipelines, Ltd, Edmonton, Alberta	30	10	Alexander field near Edmonton to Pembina field
Mississippi River Fuel Corporation, St. Louis, Missouri	190	10–18	Laterals in Texas
Montana-Dakota Utilities Company, Minneapolis, Minnesota	41.8	12	Tioga-Beaver Lodge field in North Dakota to main transmission line
Morganfield Natural Gas Company	31	4–6	New lines in Kentucky
Natural Gas Pipe Line Company of America, Chicago, Illinois	350	20–26	Amarillo, Texas to Wise County, Texas, through Southwest Oklahoma
Nevada Natural Gas Company, Las Vegas, Nevada	114	10	Loop of present system
Northern Natural Gas Company, Omaha, Nebraska	15	24	Loops on system in Nebraska
	28	24	Ogden to Redfield storage area, Iowa
	168	20	St. Paul-Minneapolis to Duluth, Minnesota and Superior, Wisconsin
	163	10–12	Main lines in South Dakota
	307	Var.	Branch lines in South Dakota, Minnseota, Iowa, and Wisconsin
Northwest Utilities, Ltd.	42	—	Bonnie Glen to Edmonton, Alberta
Offshore Gathering Company, Houston, Texas	364	30	Offshore gas line in Gulf of Mexico from Sabine Pass to Mississippi River.
Pacific Gas & Electric, San Francisco, California	150	34	Loops on Topock, Arizona to Milpitas, California, system
Panhandle Eastern Pipe Line Company, Kansas City, Missouri	58	16	Peoria to Springfield, Illinois
	20	24	Rolla to Hugoton, Kansas
	74	4–16	Loop lines and replacements on system
Pioneer Natural Gas Company, Amarillo, Texas	261	3–22	New lines, loops, replacements and irrigation feeder lines Panhandle and South Plains of Texas
Pine Tree Natural Gas Company	204	—	Boston, Massachusetts to Bangor, Maine
Shenandoah Gas Company, Winchester, Virginia	39	3–8	Middleton, Virginia to Martinsburg, West Virginia
Southern Counties-Southern California Gas Companies, Los Angles, California	236	30	Topock, Arizona to Newhall, California.
Southern Natural Gas Company, Birmingham, Alabama	39	—	Loops on system
Tennessee Gas Transmission Company, Houston, Texas	221	26–30	Loops in Ohio and Kentucky
	100	—	New gathering lines in Texas and Louisiana
	162	—	Loops in Kentucky, Ohio, and Pennsylvania
	335	6–24	Gathering system in South Louisiana
Texas Gas Transmission Corporation, Owensboro Kentucky	105	10–12	Eunice to Morgan City, Louisiana
	81	8–30	Loops on system
Trans Canada Pipe Lines, Ltd., Calgary, Alberta	2247	14–34	Alberta area to Toronto, Montreal, and other eastern Canada areas
Union Gas Company of Canada	180	—	Dawn Storage Field to Hamilton, Ontario
United Natural Gas Company	50	12	Elk county to Jefferson county, Pennsylvania
Utah Natural Gas Company, Salt Lake City, Utah	40	16	Orem to Salt Lake City, Utah
Virginia Natural Gas Company	153	—	Buckingham to Richmond and Portsmouth, Virginia

There's **MORE** rating selection available in Allis-Chalmers **MOTORS**

To meet refinery needs... Allis-Chalmers Offers Complete Line of Rib-Type Motors from 1 to 100 Hp



Made to order for refinery use, Allis-Chalmers explosion-proof, rib-type motors are available in ratings from 1 to 100 hp. The many cost-saving features of deep-rib construction can be applied in a variety of uses... both indoors and out.

Here's why these motors can cut refinery costs:

MORE cooling surface

Rib-type design provides reserve cooling capacity in dirty locations.

MORE iron

Cast-iron frame and external parts assure rigidity and resistance to corrosion.

MORE copper

A-C's greater use of copper increases electrical life.

MORE lubrication provisions

Provision made for in-service relubrication — important where corrosive vapors contaminate grease.

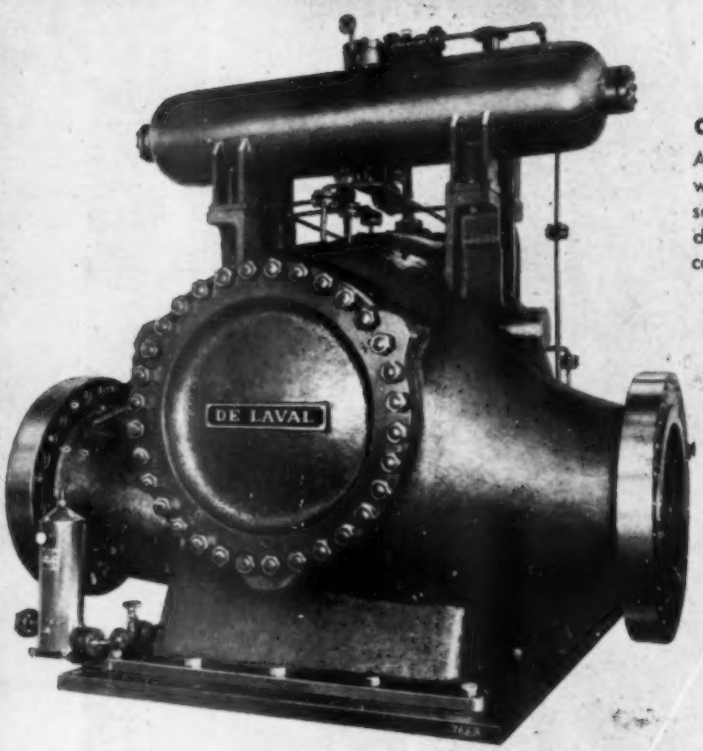
As a new machinery component or as replacement, specify Allis-Chalmers. To find out more, contact your nearby Allis-Chalmers distributor, district office, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

A-4896

ALLIS-CHALMERS

DE LAVAL
CENTRIFUGAL PIPELINE COMPRESSORS

come in two "packages" for easy installation

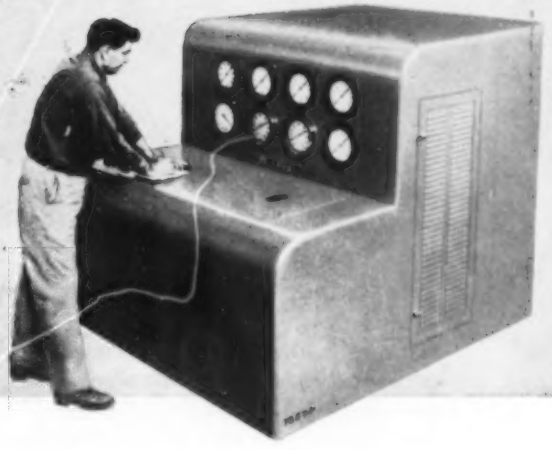


COMPRESSOR

A De Laval compressor with its emergency seal tank mounted directly on the compressor.

CONSOLE

The console contains the filters, motor-driven pumps, coolers, pressure switches, gauges and other accessories. It eliminates complicated piping on the packaged compressor . . . also serves as a protective cover for the equipment it houses.



Bulletin 503 gives data on De Laval centrifugal pipeline compressors. Write for your copy.

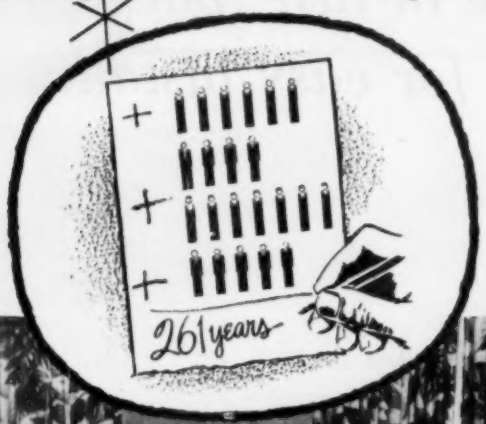
Designed in two packages, rugged De Laval centrifugal compressors offer many important engineering features. Among these are • high pressure contact shaft seal which eliminates gas leakage • heavy and rigid construction throughout • high load carrying capacity. The compressor and console arrangement makes De Laval centrifugal compressors easy to install—only simple low-cost foundations are required. De Laval units, totaling more than 280,000 horsepower, are now in operation on major pipelines.

DE LAVAL *Centrifugal Compressors*

DE LAVAL STEAM TURBINE COMPANY
869 Nottingham Way, Trenton 2, New Jersey

DL-332

Among Hill, Hubbell's "Things That Money Can't Buy" we listed:



261 years of stick-to-it experience

This is what we mean

The men in this photograph are executives, salesmen-engineers, superintendents and supervisors of Hill, Hubbell and Company—and their years of experience *with this company* add up to 261!

That's an imposing figure—but doubly so when you consider that those 261 years of experience represent a practical, down-to-earth balance between work in the plant and in the field.

Hill, Hubbell was the pioneer in pipe protection, and developed many of the machines now generally in use. But machinery is not enough. The judgment and experience of men like these assure Hill, Hubbell's continuing top place in the industry. Ask for Hill, Hubbell's "Pipeline Pictorial"—the story of pipe protection in pictures.

HILL, HUBBELL and COMPANY

Factory Applicators of Pipe Coatings and Wrappings

DIVISION OF GENERAL PAINT CORPORATION

3091 Mayfield Road • Cleveland 18, Ohio

LEADER IN PIPE PROTECTION FOR MORE THAN A QUARTER CENTURY

G.E.'S NEW ENGINE-DRIVE WELDER GIVES YOU . . .

Steady Welding Output—at Full Load; Improves Weld Quality, Costs Less Too

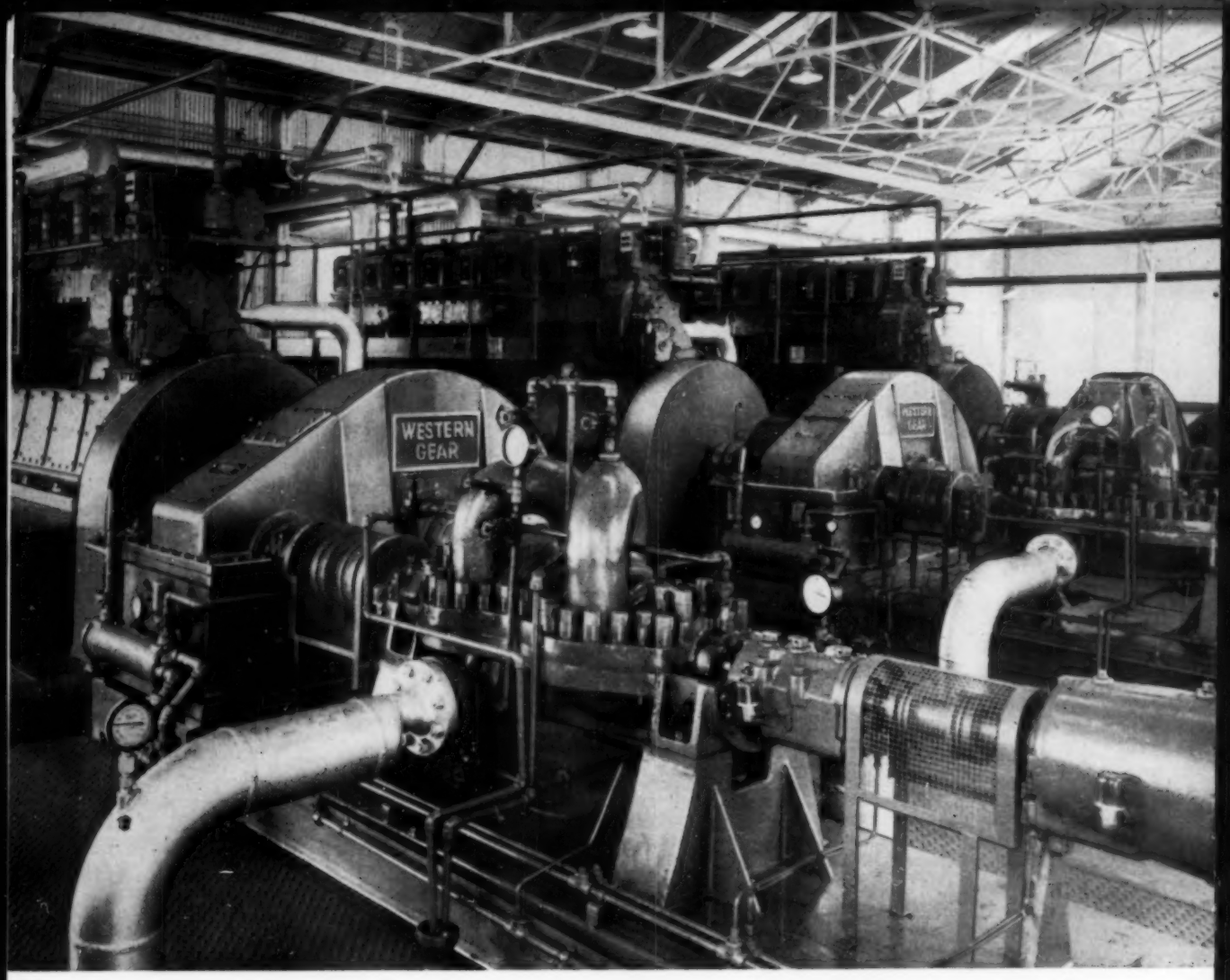
If you're using more than a 200-amp engine-drive welder for light to medium-heavy construction, you may be losing money. You may be paying for inefficiency—compensating for excessive loss of amperage and arc heat when operating at full load for sustained periods.

Now, with G.E.'s new 200-amp engine-drive welder, it's not necessary to buy more expensive, higher rated machines for pipeline, light construction, or job-shop work. This field-tested welder gives you steady output and 100% arc stability, hour-after-hour, even when operated ***above*** full load.

Test this powerful new welder yourself, and see the many advanced design features—new slow-down control, extra-rugged construction, and many others. Contact your nearby G-E Welding Distributor today. He's listed in the yellow pages of your phone book. Section 714-3, General Electric Co., Schenectady 5, New York.

EXTRA-STURDY construction is shown in this demonstration. Five nickels stand on edge while welder is operated at full load.

GENERAL ELECTRIC



3 Western Gear speed increasers specified for Warren Petroleum tandem pump installation

When Warren Petroleum Corporation expanded its field processing plant No. 37 at Antioch, Oklahoma, it installed pumps in tandem to circulate absorption mineral seal oil over three separate absorbers. These dual pumps are part of the re-cycling process of natural gas in the production of petroleum products.

Three Model 300HS100 Western Gear high speed units driven by Cooper-Bessemer natural gas engines rated at 675 HP at 450 RPM, were selected to drive these United Centrifugal pumps at 3400 RPM, pumping 1000 GPM.

Several important reasons were behind the specification of Western Gear high speed units. Western Gear's engineering service assured the correct drive selection and the extensive experience in this field enabled Western Gear to provide thoroughly tested and proven designs, with units exactly right for the job to be done.

Sixty-seven years of experience plus the best in facilities and production personnel backed by expert engineering makes a combination that's hard to beat! Whatever your pumping requirement, you can rely on Western Gear units for correct design, ruggedness and dependability. Ask Western Gear engineers for help. They'll gladly give recommendations without obligation. Address General Offices, Western Gear, P.O. Box 182, Lynwood, Calif.

"The difference is reliability" • Since 1888

WESTERN GEAR *Corporation*

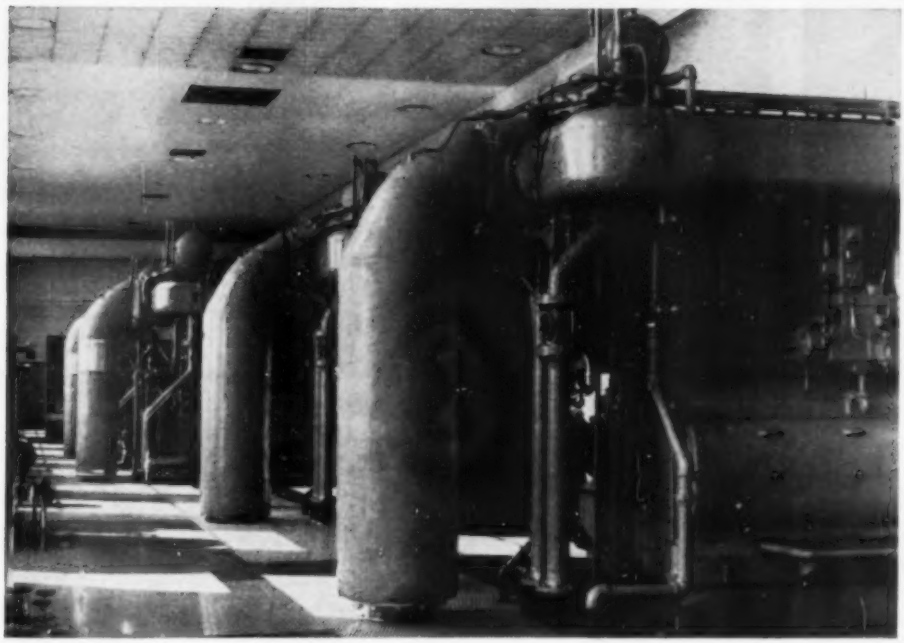
ENGINEERS AND MANUFACTURERS

PLANTS AT LYNWOOD, PASADENA, BELMONT, SAN FRANCISCO (CALIF.), SEATTLE AND HOUSTON — REPRESENTATIVES IN PRINCIPAL CITIES

Another Pipe Line Company Reports

2 to 3 times more horsepower hours

. . . after installing Koppers Conformable Oil Rings



Koppers Porous Chrome* Rings. Porous chrome surface holds and distributes oil during break-in. Seats quickly. This chrome prevents grit from embedding in ring surface. Prevents cylinder wall scratching. Reduces wear 50%. Last 4 times longer than other rings.

Koppers Conformable Ring maintains constant unit pressure for positive oil control. Conforms readily to meet cylinder distortion because flexible cast iron member is pressed outward by abutment type spring which exerts uniform radial pressure around entire circumference.

*Van der Horst Process

Here's proof that Koppers Piston Rings increase operating efficiency.

Prior to using Koppers Conformable Oil Rings, a pipe line company reported average oil consumption as approximately 3500 to 4000 horsepower hours per gallon. Now they are getting 2 to 3 times that much.

In addition to this large saving in oil consumption, they find they get longer periods of satisfactory operation between overhauls.

As a result, this pipe line company has adopted Koppers Piston Rings as standard equipment on all their 12½" x 13" turbo-charged engines.

Does this suggest possible savings in your operation? Less oil consumption? Less down time, lower labor costs? Then investigate Koppers Porous Chrome* and Conformable Oil Rings. And install them next time you have a piston ring replacement job.

Write for special assistance from our experienced technical staff. No obligation, of course . . . . and mail the coupon for special conformable ring folder.

KOPPERS®

AMERICAN HAMMERED

Industrial Piston Rings

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • Baltimore, Maryland

This Koppers Division also supplies industry with Fast's Couplings, Aeromaster Fans, Koppers Electrostatic Precipitators and Gas Apparatus.

Engineered Products Sold with Service

KOPPERS COMPANY, INC., ***Piston Ring Dept.,*** **1591 Hamburg Street, Baltimore 3, Md.**

Gentlemen: Please send me full information on your Conformable Oil Ring.

Name.....

Company.....

Address.....

City.....Zone.....State.....

To obtain more information on products advertised see page E-41

C. C. Bledsoe

Earl Allen

John H. Williams

OUTSTANDING PROGRAM ARRANGED

PL Contractors Meet in Florida

The Pipe Line Contractors Association this year has chosen the sunny state of Florida for its annual convention. The eighth meeting of this organization will be held at Boca Raton, January 16-18 at the Boca Raton Hotel and Club.

An interesting and entertaining program has been arranged, featuring outstanding speakers, and business sessions to consider industry problems. The detailed program follows:

Sunday, January 15

6:00 P.M. Pre-convention party for contractors and their wives only. Cathedral Room.

Monday, January 16

9:30 A.M. Bus tour for all ladies attending the convention, courtesy Allis-Chalmers Manufacturing Company. (Tour includes points of interest in Miami and Miami Beach, and luncheon at the Garden Restaurant.

10:00 A.M. General Business Session—Auditorium (open to all).

1. H. C. Price, President, presiding.
2. "Relationship Between Federal Power Commission and Pipe Line Companies"—W. C. McGee, Jr., Sr. Vice President, Tennessee Gas Transmission Company, Houston, Texas.
3. "The Contribution of Pipe Line Construction to the Petroleum Industry"—Frank M. Porter, President, American Petroleum Institute, New York, New York.
4. "The Effect of Atomic Energy on the Petroleum Industry"—Gordon Dean, Lehman Bros., New York, New York (Formerly Chairman, Atomic Energy Commission).

12:00 Noon Cocktails in Cloister Lounge and Luncheon in Patio Royale for all men. Courtesy M. J. Crose Manufacturing Co., Inc. of Tulsa, Houston, Denver, Newark, and Edmonton.

6:00 P.M. Cocktails and Steak Roast, Cabana Club. Courtesy Caterpillar Tractor Company, Peoria, Illinois.

Tuesday, January 17

10:00 A.M. Closed business session for regular members only. Auditorium.

1. H. C. Price, President, presiding.
2. Presentation of awards for safety achievements.
3. "Recent Developments in Welding Research" — Paul Reed, Pipe Line Editor, *Oil and Gas Journal*, Tulsa, Oklahoma.

12:00 Noon Luncheon and style show by Neiman-Marcus in Patio Royale. Courtesy Crutcher-Rolfs-Cummings, Houston, Texas.

2:30 P.M. Closed business session for regular members only. Auditorium.

1. Reports of committees.
2. Election of officers and directors.

6:00 P.M. Cocktails in Cloister Lounge and Cloister Loggia. Courtesy International Harvester Company, Melrose, Illinois.

7:30 P.M. Annual banquet and floor show—Patio Royale.

Wednesday, January 18

8:00 A.M. Meeting of Board of Directors.

10:00 A.M. Meeting for regular members only for discussion of labor matters.

Richard A. Gump

O. R. Burden

R. A. Conyes

President Price Reviews Progress

H. C. Price

The year 1955 marks the eighth year since the organization of the Pipe Line Contractors Association. A small group of contractors formed the nucleus of the organization in the fall of 1947 and its organization was completed early in 1948.

The broad general purpose for which the association was organized, and which still serves as the reason for its existence, is to provide a medium for the exchange of information concerning mutual problems affecting contractors engaged in the construction of cross-country oil, gas, and products pipe lines.

Probably 90 per cent of pipe line construction in the United States is done by members of the association. More and more the association has been recognized by the petroleum industry as the focal point for matters concerning pipe line construction.

Representatives of the association have served on various committees of the American Petroleum Institute and the American Gas Association for the purpose of expressing the contractors' viewpoint on pipe line construction problems.

Individual members have pioneered in the development of new techniques to facilitate construction of pipe lines of larger and larger diameters to satisfy the needs of the growing demand for petroleum products.

No job has yet been presented to the pipe line construction industry that it has been unable to meet, and the contribution to the ever-expanding economy of the country has been great.

To become specific for a moment, the association has endeavored to establish uniform working conditions for pipe line construction throughout the United States and has encouraged the adoption of safety measures in construction work to reduce the number of personal injuries and property damages resulting from accidents in pipe line construction.

The association has published and distributed a safety manual for pipe line construction and distributes a monthly bulletin to encourage safety.

The association has always been ready, willing, and able to lend its aid toward the solution of any problem confronting the industry, and it is the intent of the association that membership therein will establish a standard of skill, integrity, and responsibility for the pipe line contractor.

R. P. Gregory

G. A. Manuel

N. K. McFarland

Officers and Directors of PLCA

H. C. Price, H. C. Price Company, Bartlesville, Oklahoma, President.
C. C. Bledsoe, Midwestern Constructors, Inc., Tulsa, Oklahoma, First Vice President.
Earl Allen, Associated Pipe Line Contractors, Inc., Houston, Texas, Second Vice President.
John H. Williams, Williams Brothers Company, Tulsa, Oklahoma, Treasurer.
Richard A. Gump, Dallas, Texas, Executive Secretary.

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R. A. Conyes, Conyes Construction Corporation, San Pablo, California.
R. P. Gregory, Houston Contracting Company, Houston, Texas.
G. A. Manuel, Williams-Austin Company, Pittsburgh, Pennsylvania.
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James P. Neill, Western Constructors, Dallas, Texas.
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Ray Leigh Smith, Ray L. Smith & Son, Inc., El Dorado, Kansas.

James P. Neill

S. L. Richards, Jr.

Ray Leigh Smith

The nation's network of pipe lines now totals 672,000 miles.

THE 1956 CONSTRUCTION OUTLOOK

Plenty of work for contractors, but "backlog" of plans is reduced — A steel shortage would hurt — Gas line construction outlook good.

Dean Hale
Technical Editor

1956: The construction outlook for the pipe line industry in the next 12 months is good — to the extent that most contractors will find plenty of work for their men and equipment.

But the list of prospective jobs is down at this time compared to previous years. No big "backorder" of work is reflected in the line-up of proposed or planned pipe lines, as has been the case in past years. The picture could change, however.

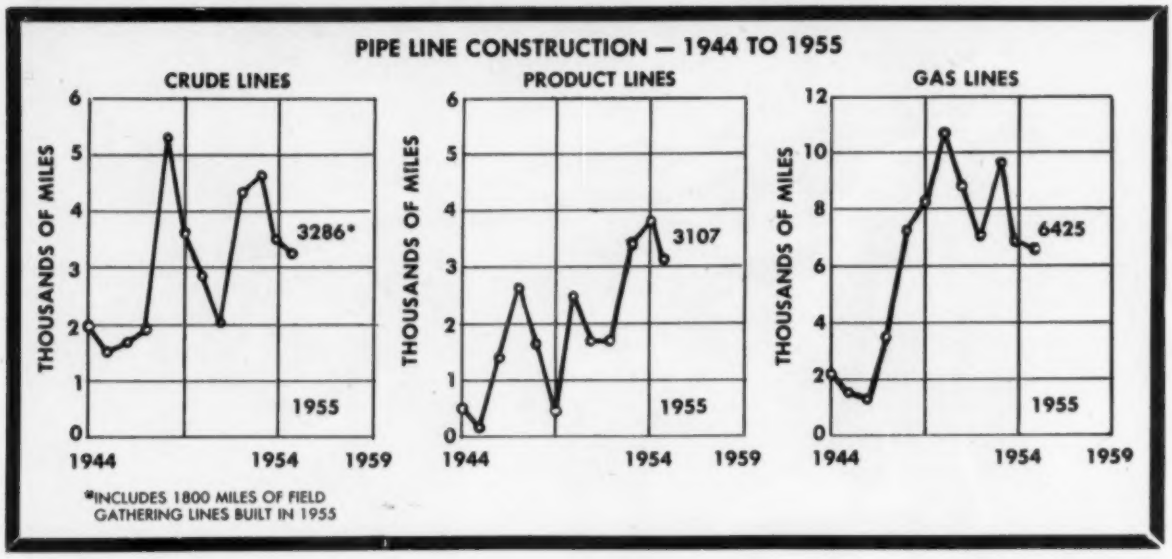
Natural gas pipe lines will provide most of the work in 1956. As of January 1, there were nearly 10,800 miles of gas line represented in the plans of some 40 companies who are proposing construction in the 1956 calendar year.

In the field of crude lines and products lines, anticipated construction is definitely down. Gone from the lists are the "longer, big-inch lines" that characterized construction in recent years. Although *The Petroleum Engineer's* year-end "outlook survey" shows some 3371 miles of crude lines and 3532 miles of products lines planned as additions to the nation's pipe line network, it should be noted that almost 2000 miles of the "planned" crude lines can be considered "doubtful" of starting this year — and for some, doubtful if ever. And of the nearly 3500 miles of products lines planned at this time, nearly 1500 miles will be conversions of existing systems.

EXCLUSIVE

Gas pipe line construction, however, will continue at a high — if not higher — level than in the past. This phase of the pipe line business was given a big "shot in the arm" in November with the FPC's approval of plans of Pacific Northwest Pipeline Corporation, El Paso Natural, and related applications on the question of importing natural gas from Canada.

As a result of that recent order, some 2000 miles of gas pipe line will most



likely get underway in 1956, part of a vast natural gas expansion program for the West Coast and the Pacific Northwest regions.

A Possible Steel Shortage?

That there may be a shortage of steel for pipe in 1956 is a possibility. It could seriously affect the construction plans of many companies.

In the past few years, because of the demand for large-diameter pipe, many mills have gone exclusively to rolling sizes 16-in. or larger, which, in turn, sometimes caused shortages in smaller diameter sizes.

The shoe may be on both feet in 1956. Some steel men have flatly predicted that many of the mills rolling larger diameter pipe may receive only 50 per cent of the steel they used last year. The reason, they say, is that demand for steel from all types of users has greatly increased, while steel mill capacity has not.

If a "steel shortage" does come, many pipe line companies may delay plans for another year on new construction or replacement and modernization jobs. There was a mild shortage of line pipe of certain types in 1955 and some jobs have already been delayed — or plans not even announced on such jobs — for that reason.

Such a shortage might also find some pipe line companies "bidding" against each other for pipe — a situation that could help get the pipe line in the ground, but one that certainly won't help the industry's overall picture in regard to costs and friendly relations.

Gas and Federal Regulation

From all appearances, the regulation of the gas industry from wellhead to the burner tip hasn't affected plans of major transmission companies, considering the amount of work planned for 1956. But it must be remembered that many of these projects were proposed prior to the 1954 Supreme Court decision, the contracts for both gas supplies and markets had been made, and most of the engineering work was done.

Only a few scattered projects of a size that could be termed "big" have made their way into the FPC's file of applications since that time. The industry, seemingly, has adopted a cautious attitude of "let's wait and see" before making any moves for even greater expansion.

The Outlook

Gas Pipe Lines. Of the nearly 11,000 miles planned or proposed, there are quite a few good-sized projects that should get underway in 1956. These are El Paso Natural's 413-mile, 34-in. line from the San Juan Basin to Topock, Arizona; 236 miles of 30-in. by Southern California-Southern Counties Gas Companies from Topock to southern California; 150 miles of 34-in. loop by Pacific Gas & Electric; loops by Nevada Natural on its system; another 900 miles of pipe line to be built by Pacific Northwest on its system, all as a result of recent FPC authorizations.

Tennessee Gas' nearly 600 miles of loop and gathering system are about ready to go. TGT's subsidiary, Midwestern Gas Transmission Company, is bidding for authority to import gas into the Middle West and will build a 1112-mile main line if it gets approval. Texas Gas Transmission is planning nearly 200 miles of loops for 1956. Westcoast Transmission Company has awarded contracts for its 650-mile, 30-in. system out of the Peace River area to the U. S.-Canadian border. Northern Natural Gas is planning more than 500 miles of additions to its system.

Crude and Products Pipe Lines. Biggest single job in this category will be the reconversion of the 1168-mile section of the "Little Big Inch" by Texas Eastern. The greater part of the work in this area will be in short lines, most of them under 50 miles and practically all of small diameter pipe. At this time, there are no really "big jobs" of long distance, large diameter caliber reported as planned or even proposed for 1956 construction.

A list of planned or proposed construction will be found on pages D-3 and D-5 of this issue in the monthly feature, "Pipe Line Developments."

1955 In Review

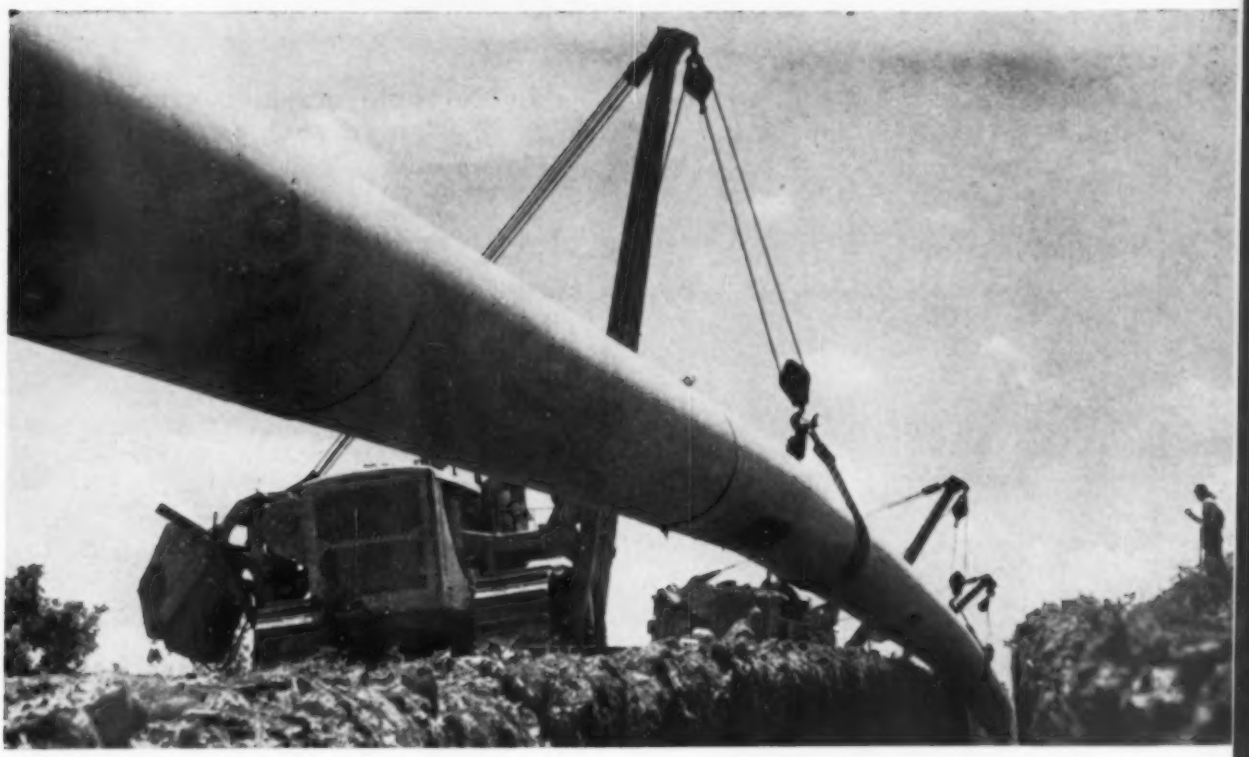
Construction activity in 1955 remained at a good level with a total of some 12,818 miles of pipe line constructed.

For the 12-month period ending December 31, *The Petroleum Engineer's* survey showed that there were approximately 1486 miles of crude lines built, 3107 miles of products pipe lines (including some 500 miles of conversion/replacement/repair), and 6425 miles of natural gas pipe lines. Additionally, some 1800 miles of field gathering lines of all types were laid in 1955.

The nation's network of pipe lines at the year's end totaled nearly 672,000 miles with the addition of the 12,800 miles of pipe line and some 10,000 miles of gas utility lines laid in 1955.

A complete report on 1955 construction appeared in the October, 1955, Oil and Gas Pipelining Edition of *The Petroleum Engineer*. ★ ★ ★

P 615.
P 620.



New Ideas Made Pipelining Faster in 1955

Originally pipelining was simple work. The pipe was strung, welded, coated, lowered-in the ditch, and covered up. Gambling, red-necked men with little or nothing to lose, would stake everything they had on laying a line anywhere. All they asked was, "Where does it start and where does it end?"

Sometimes they ended up in the chips; sometimes, they ended up with little more than their red necks. When things went bad, they often called on powers above for help, and figured a way to invoke the famed force account (or force majeure).

But today pipelining is scientific as all get out. Manufacturers are constantly bombarding the industry with new equipment and contractors are adding to their bag of technical tricks every day.

As a matter of fact, last year was without peer in this respect. Contractors figured out a way to lay the largest pipe yet in the conventional mile-a-day style. And equipment suppliers and pipe line companies contributed lavishly to the industry with new machines and new ideas.

Here are a few of the innovations that cropped up recently to speed and improve pipelining:

Donald M. Taylor
Gulf Coast Editor

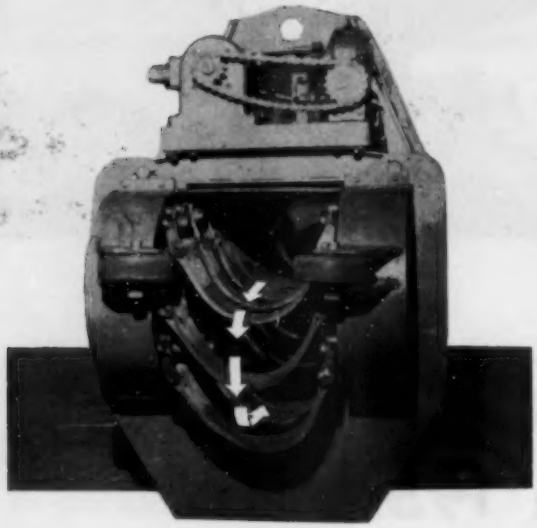
1. 36-in. pipe was laid just like 30-in.

Probably the top development in pipe line contracting during 1955 came when a number of contractors found that they could lay 0.406 wall, 36-in. pipe that weighed about 155 lb per lineal foot, using the conventional alongside the ditch method. With but little added equipment contractors averaged a mile or better per day. This was possible because equipment suppliers modified coating machines, beefed up tractors, etc., to handle the large heavy pipe.

2. Portable machine crushes 150-200 cu yd rock per hour

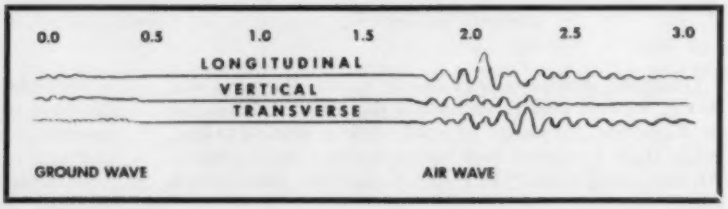
A new portable rock crusher has just made its first appearance on a pipe line job. Lone Star Gas Company is using it near Fort Worth, Texas, to reduce 12 to 20-in. boulders to padding material for ditches. About 90 per cent of the crushed rock that the machine produces will pass through a 1-in. screen.

The machine requires one operator and a tractor. This combination can process about 150 to 200 cu yd of material per hour.



3. New pipe cradle uses belts on crawler track

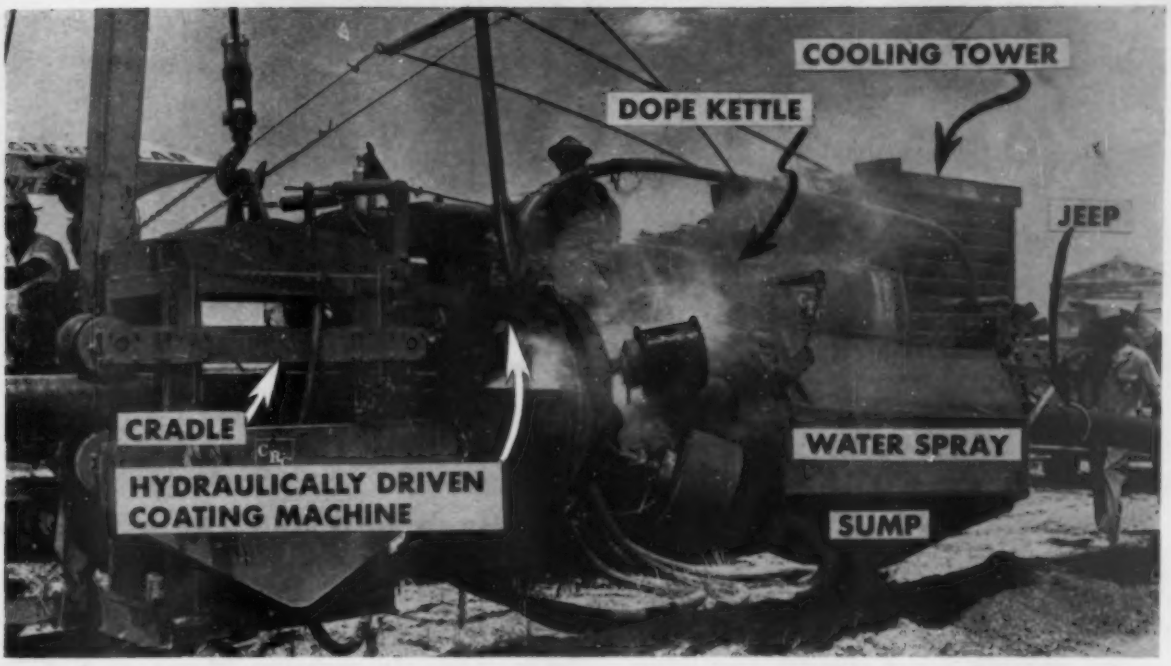
Pipe line company engineers are insisting that utmost care be given pipe coatings and, for that matter, the pipe itself. Here is a cradle that evenly distributes the weight of the pipe on a number of belts that roll around a track in much the same manner as the crawler tracks on tractors. Because of the broad area of the supporting belts, it is possible to handle newly coated pipe.



4. Seismograph makes records of rock blast

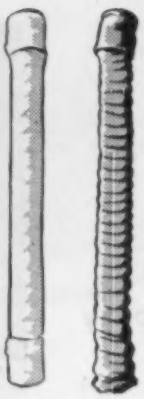
Believing that the best way to win a lawsuit is to prevent it, Associated Pipe Line Contractors (and several other contractors, too) had seismograph records made when blasting in populous areas. The record can be correlated with U.S. Bureau of Mines and insurance company criteria to prove whether a particular blast could have sufficient force to damage nearby buildings.

This prevents erroneous damage claims that sometimes arise when home owners give their houses a thorough going over after a blast, discovering for the first time cracks, etc., that already existed.



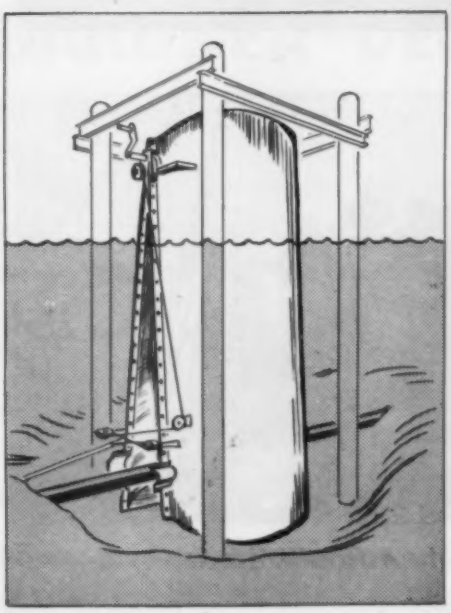
5. Coating machine, cooling tower, jeep; one package

A hydraulically driven coating and wrapping machine; a cooling tower that circulates water over coating to harden it; followed by an integrally mounted holiday detector made it possible to lay pipe line directly in the ditch on Southern Pacific Pipe Lines' new Texas to California Line.



6. Filtered water for hydrostatic testing

The way to get a clean pipe line is to keep dirt out of it. And by filtering the water used for hydrostatic testing. Transco kept a great deal of dirt out of its pipe line. Each of the twin filter units contains 120 rag and excelsior elements shown in the drawing. They give each unit a capacity of 2500 gpm. The filters were used first on Transco's $83,000,000 expansion program this past summer.

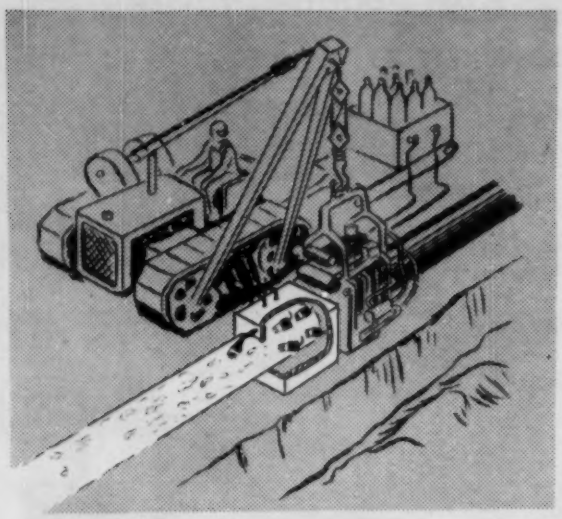


7. Hot tap was made under 22 ft of water in open gulf

A 10¾-in. line was successfully tapped 22 ft below the surface of the Gulf of Mexico. The tap was made inside a specially hinged bell that closes around the pipe in much the same manner as a clam bucket. Once around the pipe, the sides and bottom seams of the bell were bolted together using foam rubber gasket material.

Before the water was pumped out, the "bucket" was attached to four pipe piling; otherwise, the terrific buoyancy would have uprooted the pipe line.

During the tapping operations welders were shielded from overhead leaks by a tarpaulin, and a 6-in. centrifugal pump kept the water level well below the pipe line. After the tap, the hinges on the bell were cut and the two halves of the bell were removed from the sea. Care was used not to damage the 6-in. riser.



8. Flame cleaner removes 5/8-in. oxide scale from pipe

A 5/8-in. thick oxide scale on a bare line defied ordinary cleaning methods. Gulf Welding and Machine Works of Conroe, Texas, contracted to remove the scale and devised the machine shown here to do the work. The coating on the 12¾-in. line was moistened, then heated intensely by 6-in. de-scaling tips that encircled the pipe. Moisture in the coating was flashed into steam, and the coating flaked off. Two counter-rotating brushes finished the job.

The 40-mile line was cleaned at the rate of 500 ft per hr. The cost of the acetylene fuel ran 9.42 cents per lineal ft.

---

10. First large scale use of epoxy resin for internal coating

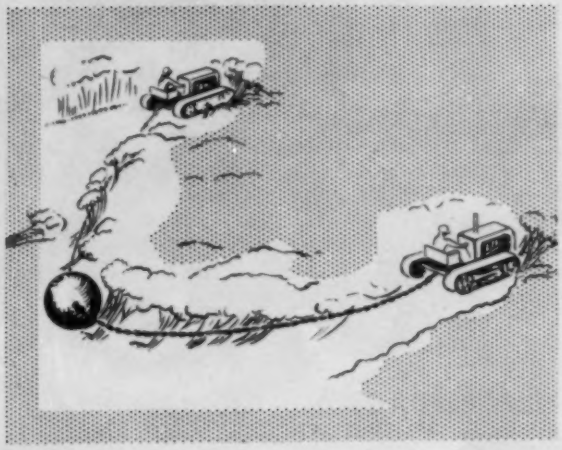
On Transco's $83,000,000 looping program, internal coating of the line by epoxy resin greatly reduced the amount of gas used for cleaning and drying the line after hydrostatic tests. Some of the squeeze pigs were driven through the line with gas pressure of only 5 psi.

Some engineers feel that the coating prevents the water from being driven into the pores of the pipe and scale during the high pressure water test, and thus greatly aids water removal afterwards. Transco engineers are hoping that the slick coating may improve flow characteristics of the completed line.

---

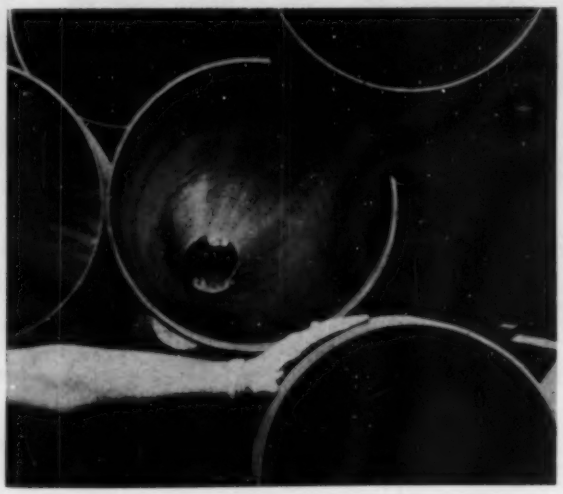
11. 36-in. coating and wrapping machine uses large wide rolls

Manufacturers played a vital role in making it possible to lay 36-in. pipe in the conventional manner, by developing cleaning and coating machines that could handle the pipe. One innovation that may find its way to smaller diameter lines was the large rolls of paper and glass, which would last as long as a kettle of dope on the big line.



9. Huge ball and chain clears right-of-way

An unusual technique was introduced into clearing operations on the Alaskan products line recently completed. It involved the use of a steel clearing ball, 6 ft in diam, pulled by two tractors. This method was effective only in small brush.



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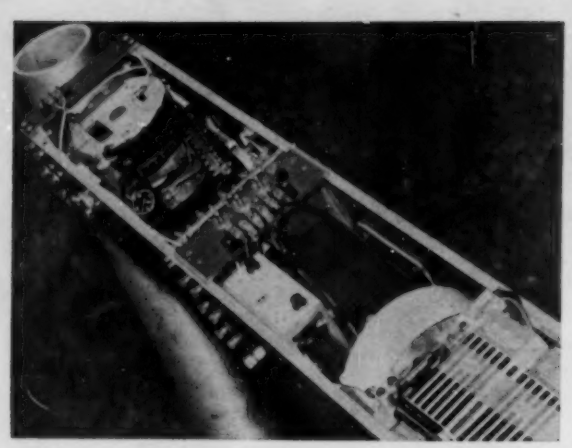


12. The "mole" accurately locates underwater lines

A gyroscopic "mole" has proved to be the best answer so far to the problem of locating underwater pipe line river crossings. The device utilizes the key instruments of oil well surveying equipment that make directional drilling possible.

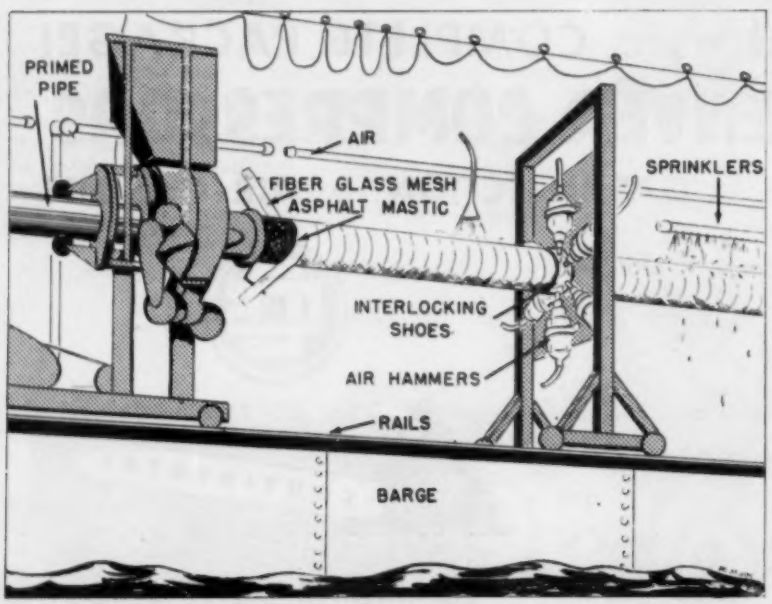
Inside the "mole" there is a gyro compass, an inclinometer, and a camera. The camera is timed to make an exposure at definite time intervals, photographing the vernier scales on the two instruments. The device in its case and on casters is pulled or pushed through the line in 40 ft intervals and the camera records the readings after the instruments have stabilized.

The survey is closed by running it backwards, and the profile and plan of the line are adjusted.

13. Offshore lines laid in bundle

Four pipe lines (an 8-in. and three 3-in.) and a large submarine telephone cable were banded together with circular straps and laid across 8300 ft of water between Seal Beach and a drilling island off the coast of Southern California. The lines were laid by Collins Construction Company of Port Lavaca, Texas. Pontoons were spaced 54 ft apart to give the bundle of lines a negative buoyancy of 4 lb in sea water.

The lines were made up in 750-ft sections welded together as they were successively launched. Afterwards the bundle was buried beneath 2½ ft of cover by Collins' submarine trencher.



14. Dual purpose coating for undersea pipe lines

Southern Production Company has developed a new, single-shot coating for underwater lines to serve both as a weight coating and a corrosion resistant coating. It is made of asphalt-mastic, filled with weight materials and slivers of glass fiber. It is extruded onto the pipe, cooled by water sprinkling, and compacted with air hammers. A double outer wrap gives it added strength. The weight of the coating runs from 130 to 240 lb per cubic feet.

Equipment is being fabricated to coat the lines from a laying barge at sea.

15. Ditcher widened to straddle 48-in. ditch

Houston Contracting Company used three machines to cut the 5- ft, 6-in. ditch of the 36-in. line in Alabama and Georgia. First there was the ripper that broke up the ditch line, then came a ditcher that cut a 48-in. ditch, and finally there was a large ditcher that cut the 51-in. wide ditch to final grade.

Distance between the tracks on the latter ditcher was increased 2 ft to safely straddle the ditch and the conveyor was lengthened.

---

16. New spacers protect enamel on concrete-coated lines

Cast concrete spacers or "chairs" that circle the pipe were devised to hold reinforcing steel in concrete-coated lines at the correct position. The chairs also space the pipe in the center of a form while the concrete is vibrated around it.

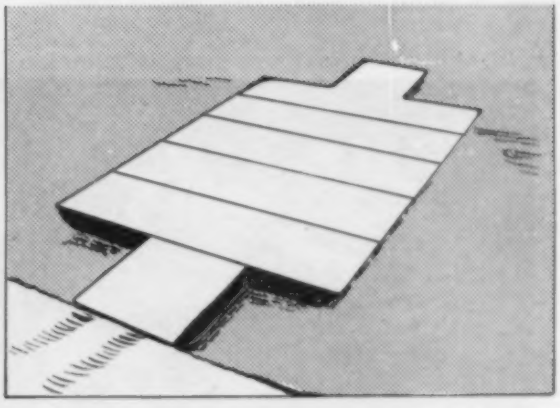
The resulting coating is smooth, and, surprisingly enough, the chairs do not show through the coating.

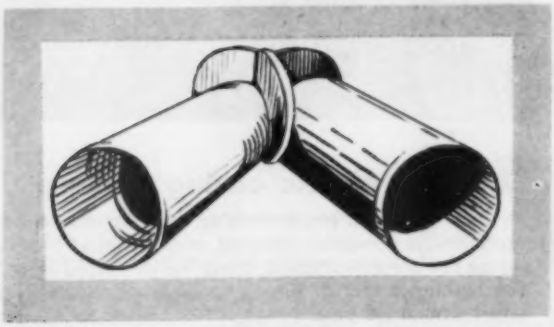
---

17. Sectional barge transported by truck

A ferry made of five 30 by 7½ by 3½-ft sections and two ramps was hauled by truck to a river crossing site on Pacific Northwest Pipe Line Company's line. The barge saved the contractor money because it saved "roading" the spread several hundred miles through mountainous terrain.

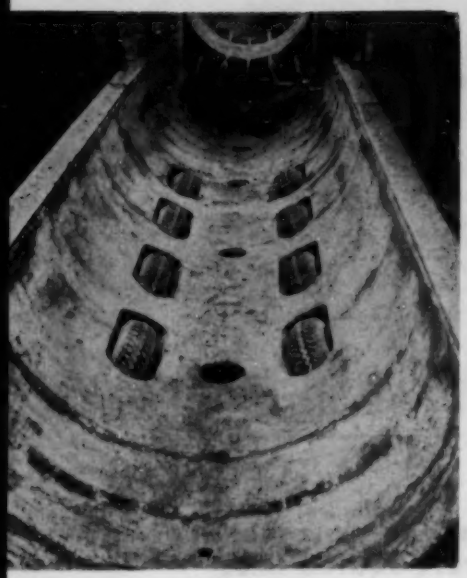
Two of the sections can be hauled on an ordinary float, and they hinge together when in use. They are made of ¼-in. steel and specially braced internally.





18. New type branch connections

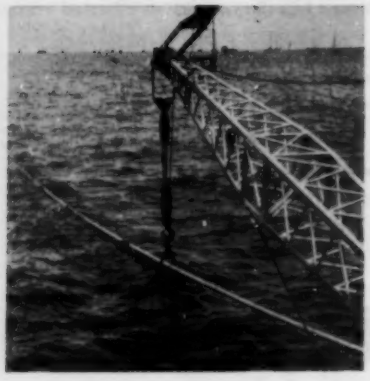
A new 30-degree branch connection features an unusual reinforcement developed in England. It is known as the Blair "triform" reinforcement.



19. Vertical benders effective on 36-in. pipe

Used for the first time on the Transco line, a new type vertical hydraulic bender was highly successful. When the pipe had been yard coated prior to bending, airplane type pneumatic tires, as shown at the right in a cable bender, were used in the forming shoes to prevent damage to the coating while moving the pipe in and out of the bender.

The hydraulic bender deformed the huge pipe as much as 18 deg.



20. Aluminum line to combat marine predators

The voracious appetite of a small aquatic animal called the Teredo has prompted the construction of the world's first permanent underwater oil pipe line of aluminum.

The 1000-ft line was recently welded and submerged in Lake Maracaibo, Venezuela. Engineered by Creole Petroleum Company with the assistance of Aluminum Company of America, the installation will carry crude oil from an underwater well of Creole's Bachaquero field to flow station on the lake shore. The 4-in. aluminum line was laid bare, and it is expected to resist the attack of the barnacle-like Teredo externally and the corrosive effects of the crude internally.

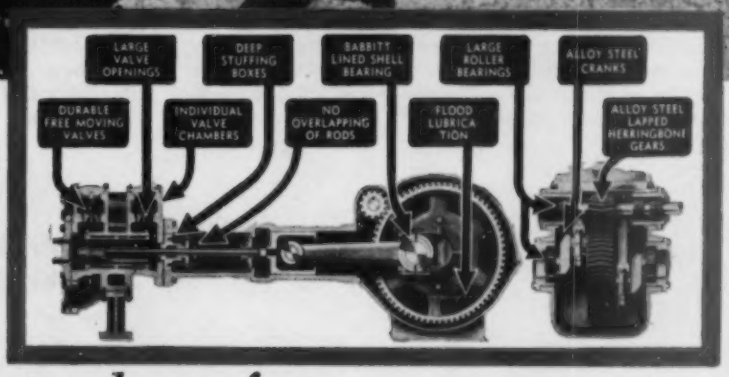
21. Pneumatic line-up clamps

Shown here in an experimental line-up clamp that depends on air tanks for power. In early tests it proved satisfactory on thin-wall pipe; however, the tank had to be changed after every eight line-ups or so.

22. New plastic casing bushing

A new laminated plastic bushing that can withstand the terrific forces sometimes imposed on bushings as a section of pipe line is winched into a casing was developed recently. The bushing comes in three circular sections, which are bolted around the pipe.

ASSURANCE STARTS WITH DESIGN



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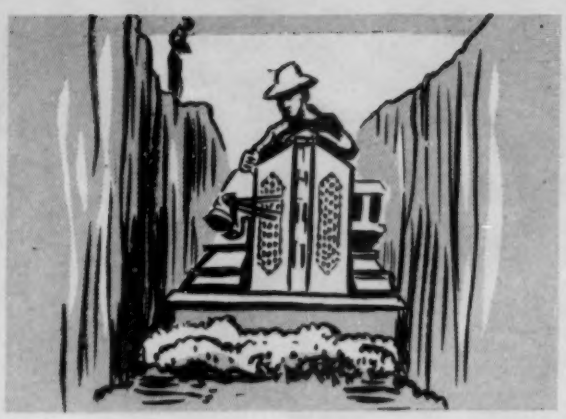
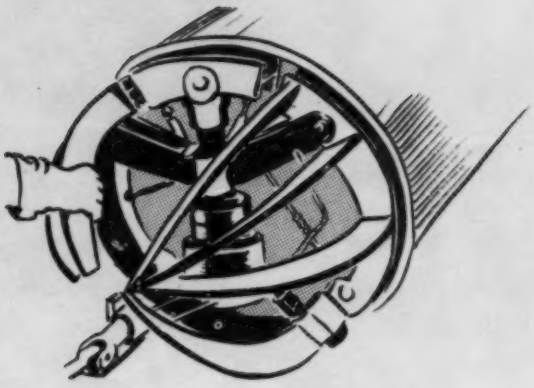


23. Small bulldozer crumbs out ditch after blasting

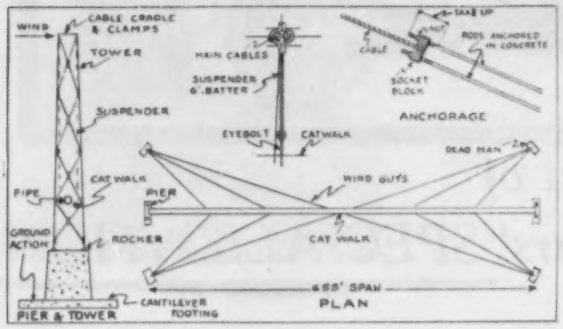
Houston Contracting Company used a miniature bulldozer to crumb out a 51-in. wide ditch after blasting, backhoe work, etc. The tractor had a 4-ft wide blade and is operated in much the same manner as any other bulldozer.

One of the interesting features of this work is that ordinarily the small machine was equipped with a flag to enable pipeliners to spot it in the ditch.



24. Electro hydraulic line-up clamps are fast and tough

Faster and tougher line-up clamps were in strong demand and several companies made improvements on the conventional clamps. One such improvement was the electro-hydraulic clamp, which, as its name implies, uses electricity to activate hydraulic power. In some cases, contractors used both external and internal clamps simultaneously to get better fit-up.



25. Prefabricated aerial pipe line bridge in Canada

An aerial span, 665 ft long carries an 8-in. natural gas line across the Bow River in Canada. The bridge was prefabricated with two 75-ft rocker towers on either side. It was erected without a great deal of heavy equipment.

Instead of using the pipe as the backbone of the bridge, the bridge supports a catwalk across which the pipe was strung. The towers are, in effect, I-beams built of smaller I-beams. They taper from a 12-ft spread at the bottom to a 5-ft spread at the top. In depth, they taper from 6 ft just above the rocker to 2 ft at the top.

26. Tractor divides into halves to facilitate shipment

This is a fairly recent development that has yet to make its appearance on the pipe line right-of-way. It has twin engines both of which transmit their power to the tracks hydraulically. The manufacturer says it can be unbolted and divided into two halves for shipment.

27. Collapsible pigs clean lines with plug-type valves

Many collapsible pigs have been developed for cleaning lines with plug-type valves. One of the most promising ones has pneumatically operated brushes. It was developed by Pete McGehee of Transcontinental Gas.

28. New 250-amp diesel engine welding machine

This machine was designed for all purposes on the pipe line. Contractors are hoping that the diesel engine will cut maintenance costs and give longer life on the firing line.

29. Sideboom tractor with rubber tires for special work

This machine proved useful in constructing large diameter lines inside and adjoining corporate city limits. Bechtel used it extensively in Westchester County New York on Tennessee Gas' pipe line.

One of the most picturesque, and also one of the toughest, pipe line construction jobs was that of the Trans Mountain Oil Pipe Line in Canada. These welders are working over Iago Jump-off, Coquihalla, Canada, British Columbia.

(Photo courtesy Bechtel Corporation)

New type coating and wrapping machine used for first time on Macco-Robertson spread constructing Southern Pacific products line. It is a hydraulic, self-cradling unit powered by an engine on the dope kettle, followed by a recirculating water-spray ring-type cooler.

Pipe Line Pictorial

CONTRACTORS ON THE JOB

Oil and gas can be found anywhere. And when they are pipe lines must be laid to make them of commercial value. The pipe line contractor is the man who connects the source with the consumer. In doing his job he is called upon to build lines through all kinds of terrain and in all kinds of weather. Shown in these pages are some of the obstacles he has to overcome and some of the techniques he uses.

The pull method was used to get this 26-in. pipe, weighted with 4500-lb cast iron clamps, in place across the Kentucky River just below Kentucky Dam. Pentzien, Inc., did the job for Texas Gas Transmission Corporation.

Road crossings are necessary and commonplace, but highly developed equipment and techniques have placed them in the category of routine pipelining. Oklahoma Contracting Co. made this one for Tennessee Gas Transmission Co. on its Hebron-Greenwich line in Pennsylvania.

During construction of a 22-in. natural gas line for Colorado Interstate during 1955, Houston Contracting Company installed this crossing of the South Platte River in Colorado. Concrete river clamps were used to give the pipe negative buoyancy.

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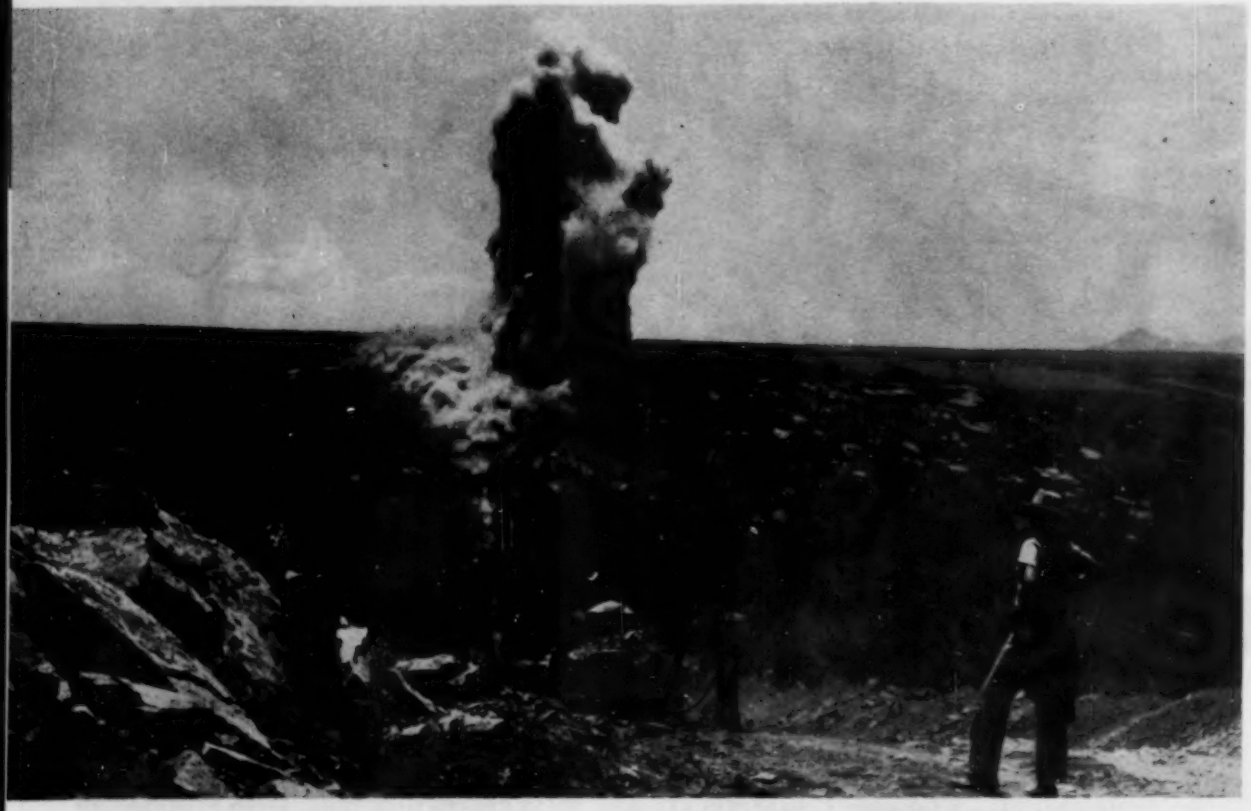
During 1955 Transok Pipe Line Company built a 24-in. natural gas transmission system from Lindsay to Tulsa, Oklahoma, entirely within the state in order to avoid FPC jursidiction. Pipeline Service Company was the contractor. The crew is making a pipe bend.

Framed by the opening of a length of 26-in. pipe, giant side-boom tractors hold suspended part of a pipe line loop built for Tennessee Gas Transmission Company near Oak Hill, Ohio, by H .C. Price Co.

The Pacific Northwest Pipeline, which will provide the northwestern part of the United States with its first natural gas, got underway in 1955 and will be completed during the summer of 1956. R. H. Fulton & Co. here blasts a trench in rocky country between Cahone and Dove Creek, Colorado.



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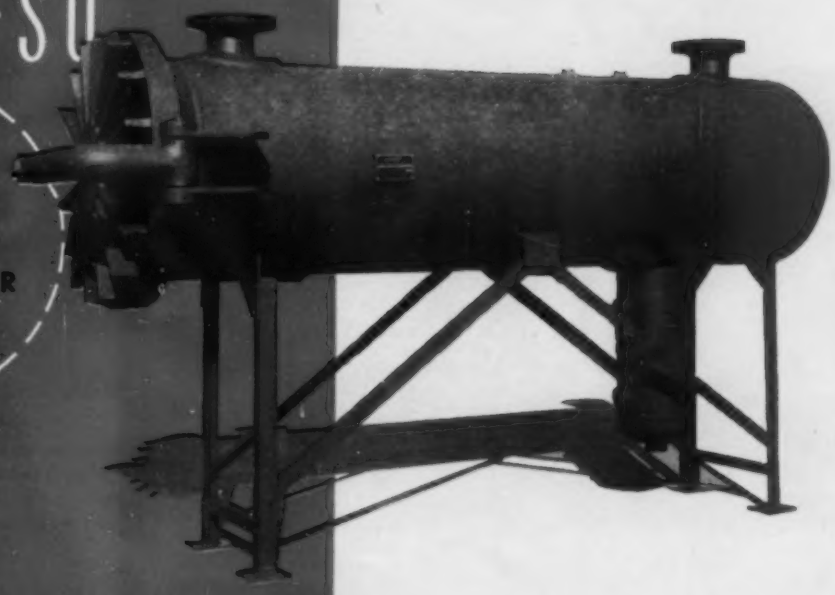

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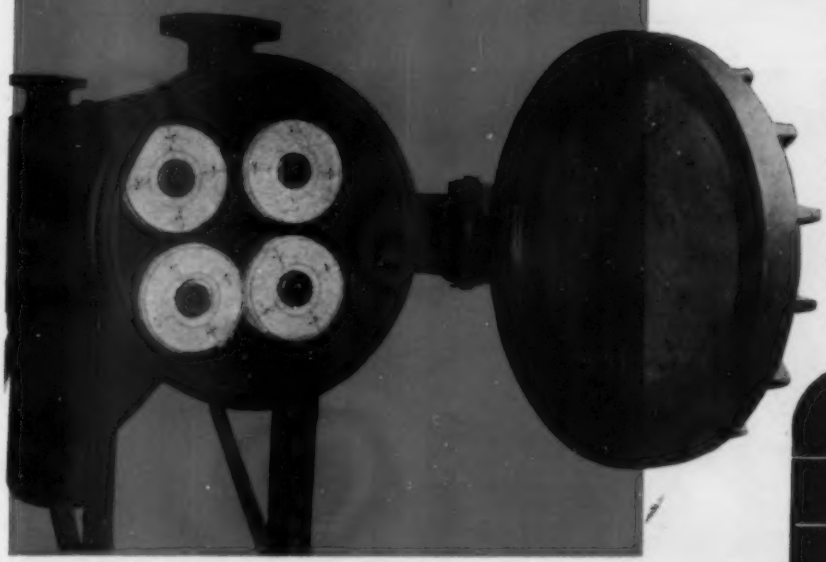

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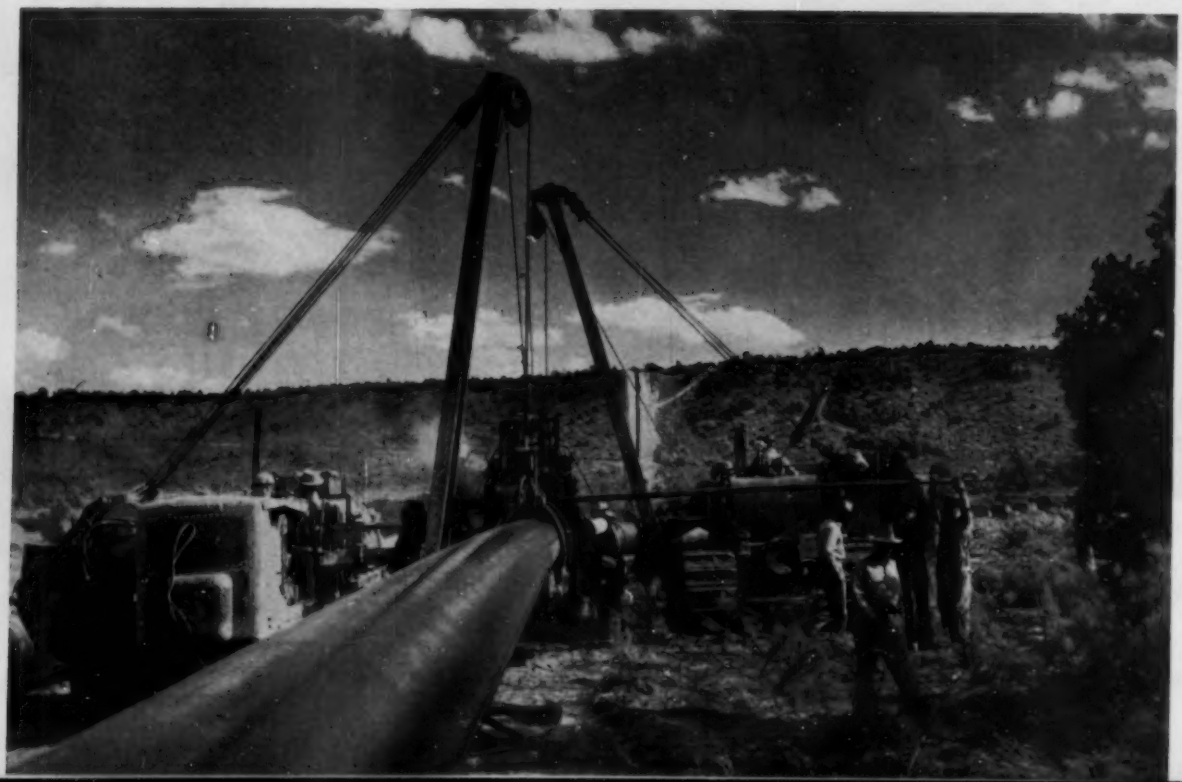
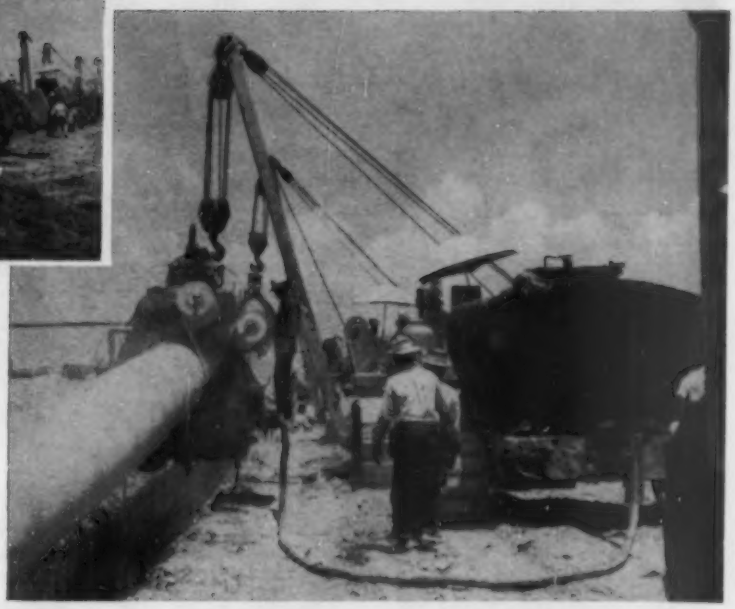
Route of Pacific Northwest Pipeline is partly through high as well as rough country. This photograph was taken in Douglas Pass at an elevation of 6000 ft and shows the contractor's equipment (R. H. Fulton & Co.) clearing and grading the right-of-way.

(Photo courtesy Fish Northwest Constructors, Inc., agent for Pacific Northwest)

Another scene on the Pacific Northwest Pipeline system. A River Construction Corporation crew is coating and wrapping 26-in. pipe on Section 2, which is in Utah. Not all of the line was through mountainous country, as this picture shows.



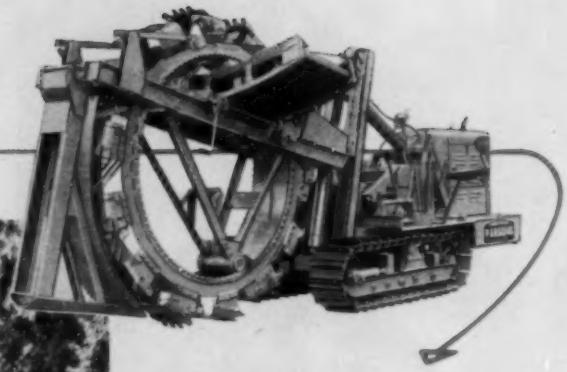
Transcontinental Gas Pipe Line Corp., which pioneered the laying of 36-in. pipe, constructed 315 more miles of this super-inch pipe line in 1955. To lower in the pipe, Western Constructors, on its section, used six side-boom tractors with slings, leapfrogging the tractors.

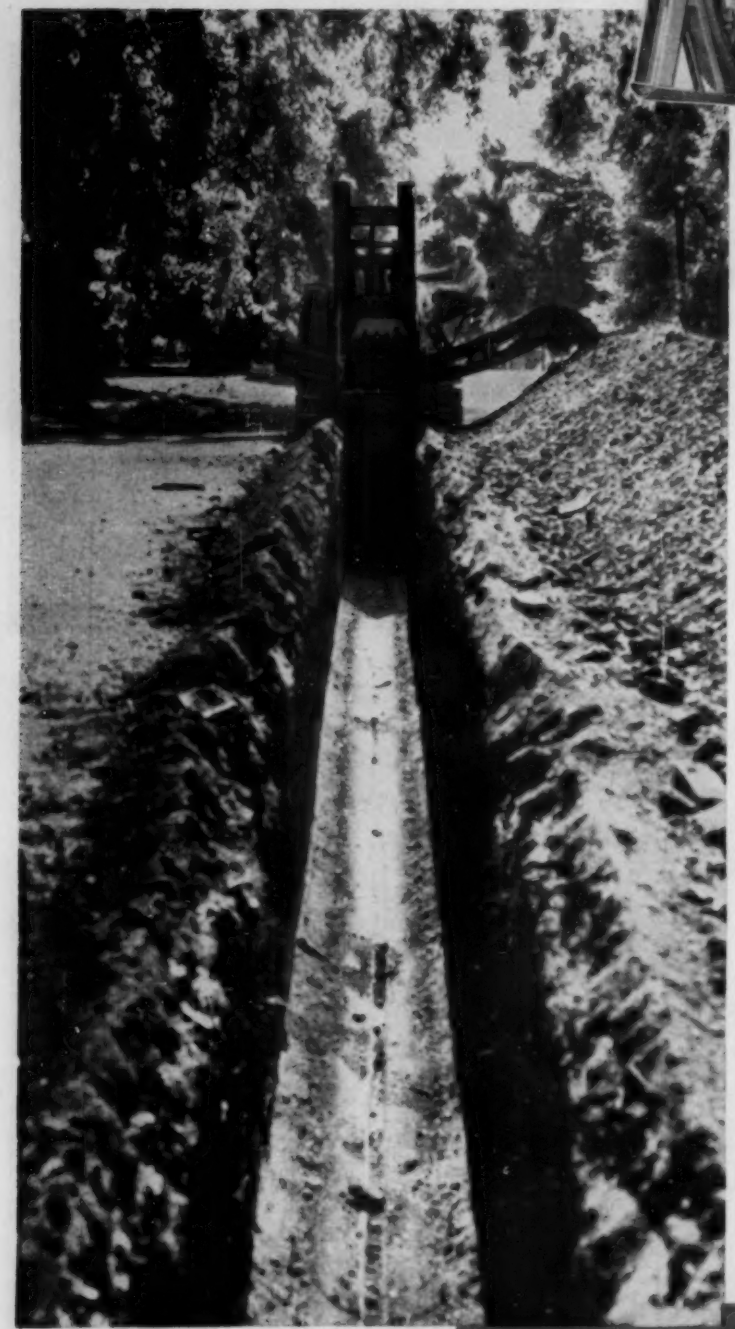


Naturally, less equipment is needed to lower in 30-in. pipe. Here Panama-Williams Corporation lowers pipe into the ditch, after coating and wrapping, using three side-boom tractors. Transco job.

Associated Pipe Line Contractors encountered some difficult terrain on its section of the Pacific Northwest Pipeline. This Utah rock had to be blasted plenty to make ditch and special care taken to pad the ditch before lowering in.

Digs up to 1500 FEET per hour





Parsons 150 Trenchliner sets a fast pipeline pace on cross-country transmission lines, feeder lines, and gathering systems. For example:

30 digging speeds, from 12 inches to 25 lineal feet per minute, assure maximum trench production at every depth, width, and in all soil conditions.

6 trench widths range from 16 to 26 inches wide — and maximum digging depth is 5 feet 9 inches.

Holds accurate grade — Hydraulic ram on vertical mast raises and lowers the digging wheel, maintains close grade tolerance. (A separate ram tilts the mast, balances weight of wheel forward for traveling or trailer-loading.)

Cast-steel buckets, solid-type or tine-back, have self-sharpening reversible "Tap-In" teeth or gumbo buckets to suit dry or wet digging conditions.

Dual-purpose friction clutch drives the digging wheel, and automatically protects machinery against shock loads.

Shiftable, reversible belt conveyor, 24 inches wide, discharges spoil to either side — 3 belt speeds on conveyor.

Standard tractor crawlers have 16-inch grouser-type shoes with replaceable links, bushings, pins. Ground-bearing pressure is low — only 6.3 lbs. PSI.

Choice of 2 standard engines — 60 h.p. gas or diesel. Better check how this 150 Trenchliner fits into your pipeline spread for main-line trenching — or as an auxiliary production unit for digging laterals.

Your Parsons distributor has more information that will interest you. See him, or write.

6 other sizes of Trenchliners® in the Parsons heavy-duty line include wheel and ladder-type machines, full crawler mounted — and a small, utility-size Trenchmobile® on rubber tires.

(Koehring Subsidiary)

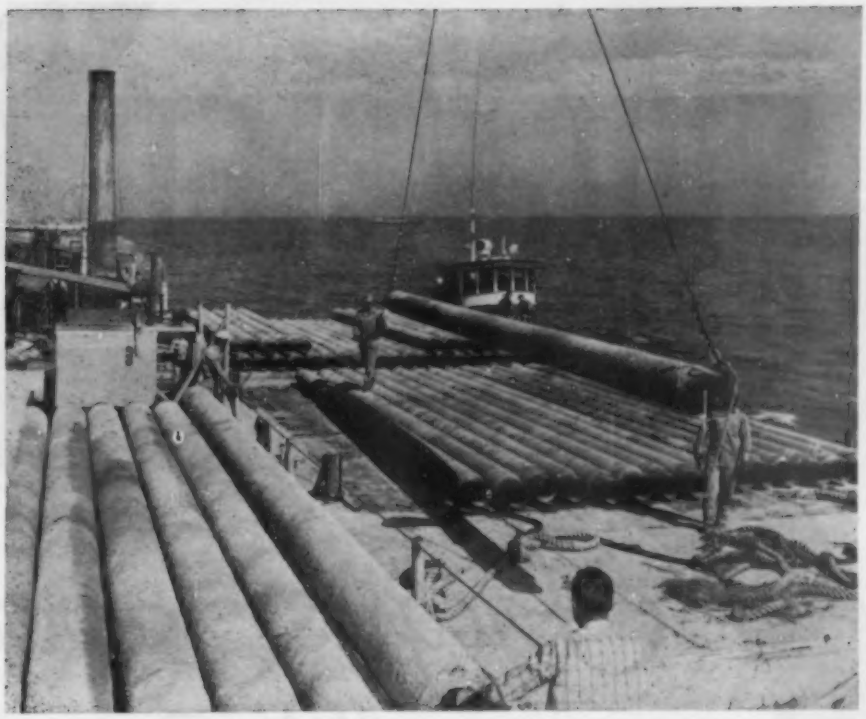
Send bulletin on Model 150. **PARSONS COMPANY,** NEWTON, IOWA

NAME ..... TITLE .....

COMPANY ..... DIV. .....

STREET .....

CITY ..... STATE PS52PE



Laying pipe lines underwater has become quite a technique. Brown & Root laid 50 miles in the Gulf of Mexico off the Louisiana coast for Continental, Magnolia, and Newmont. This view shows cured pipe being transferred from a pipe supply barge to the lay barge.

This underwater operation was performed for the Marine Gathering Company offshore from Cameron Parish, Louiana. The heavy-type coating serves to give the pipe weight as well as protection. Sam Carline, Inc., contractor.

UNION CENTRALIZED

Progress Report 1955

To crude, product and natural gas pipelines

TRANSPORT CONTROL

At the end of 1955, we had accumulated 25,000 miles of centralized control experience in long haul transportation.

In the pipeline industry, the assignments we have undertaken have been challenging and have made use of our extensive engineering knowledge in the control field. When competent control and pipeline engineers get their heads together and apply their many years of experience to the problems present, the results are bound to be good.

THEY HAVE BEEN!

The solution of these control problems on a pipeline recognized the system approach. Not just one station —pump—or valve—but everything on the line was considered as an important and integral part of the system function. Because the prime objective was the fast and efficient movement of liquids and gases over long distances, the complete operation was surveyed and analyzed where pipelines desired it.

Therefore, we have designed control systems for pipelines by applying our engineering philosophy that has been 75 years in the making.

Now in service, UNION systems are accomplishing the following:

1. Partial system control including:
   a. Coordinated control and indication of valves and pumps throughout the portion of the system under control.
   b. Coordinated control of valves determining stream destination at line switching center in the system.
2. Injection pump control and indication and metering.
3. Booster pump control and indication and metering.
4. Booster pump control and data handling.
5. On-the-line internal combustion engine driven gas compressor station control and indication including the remote control of governor set point and data handling.
6. Telemetering to indicate and record interface arrival at the switching center.
7. Alarm indications and automatic shut down of units caused by such faults as: (a) High pump outside bearing temperature. (b) High pump inside bearing temperature. (c) High pump case temperature. (d) High motor outside bearing temperature. (e) High motor inside bearing temperature. (f) High motor winding temperature.
8. Automatic sequencing of valve and pump functions.

The basic system features a high degree of flexibility. It works well over any communications medium: telephone circuits, carrier circuits, VHF and UHF radio and microwave, as well as private wire.

a. It is easily adaptable. The equipment is so constructed that additions or modifications can be made with a minimum investment. Clean and uncluttered, it is functionally designed to fit existing installations.
b. It is reliable. As one well-known pipeline engineer said, "it goes to work — and keeps on working."

UNION Centralized Transport Control can be used on a variety of pipeline layouts, gathering systems, tank farms and other applications requiring remote control. Let us show you *specifically* what it can do for you. Working on a specialist-to-specialist basis, we shall be glad to discuss your control problems. Write for complete information.

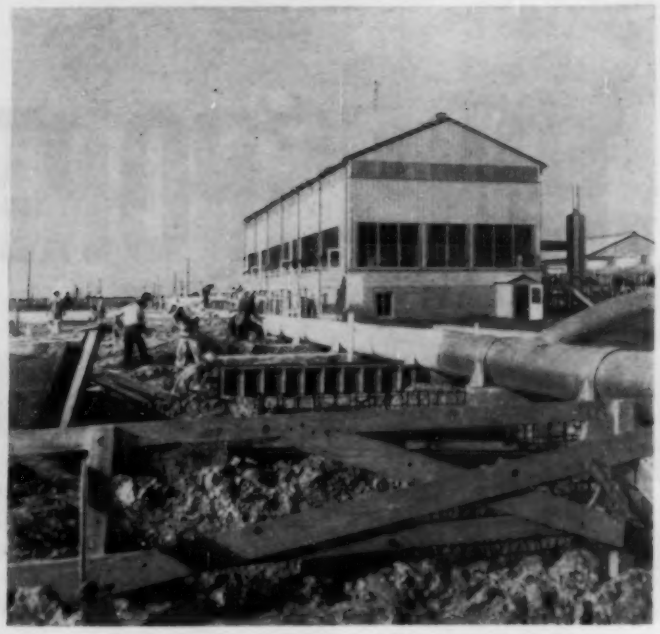
GENERAL APPARATUS SALES

UNION SWITCH & SIGNAL

DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY

PITTSBURGH 18 PENNSYLVANIA

CHANNEL CROSSING. TGT's line was laid 55 ft beneath the surface of the Houston Ship Channel.



STATION ADDITIONS at Station 507, at the end of the Agua Dulce-Kinder line, Kinder, Louisiana, near completion.

TENNESSEE GAS

Is Bustin' Out All Over

With a 250-mile New York area job completed, a 370-mile Gulf Coast line nearing completion, and a 355-mile gathering system about ready for construction, TGT is looking towards north central U.S. markets; the company is giving aid to Trans-Canada as a starter

EXCLUSIVE

A 10,000-mile natural gas pipe line system may become a reality for Tennessee Gas Transmission Company before too long.

Work on an important 370-mile, 30-in. line between Agua Dulce, Texas and Kinder, Louisiana, is now entering into the final stages of construction.

TGT has just completed a big expansion into the New York area, encompassing 250 miles of 24-in. line from the Hebron Storage field near Coudersport, Pennsylvania, to near Greenwich, Connecticut.

Further, the company is getting ready to start work on a new 355-mile, 6 to 24-in. gathering system in the watery world of South Louisiana, already affectionately dubbed "The Muskrat Line," that will add substantially to the gas reserves accessible to TGT.

Another 221 miles of loop line to be added in Kentucky and Ohio have been authorized by the FPC, along with 21 miles of gathering line in Texas.

Totaled up, these new facilities will give TGT a system of 9287 miles — and the distinction of having the nation's biggest pipe line system.

But there's more to come.

The company is laying plans to further expand its present system, and also expand into the north central U. S. and Canadian markets through a subsidiary company, Midwestern Gas Transmission Company. The latter will

hook onto the first leg of Trans-Canada Pipe Lines, Ltd., in which TGT now has an active financial interest.

Midwestern's proposed system would include 1112 miles of main line, plus 648 miles of extensions to serve its customers. Application for authority to construct these new facilities was made in October.

At the same time, TGT filed two other allied applications that would add some 100 miles in gathering lines in Texas and Louisiana, and 162 miles of loop lines in Pennsylvania, Ohio, and Kentucky. *See Page D-64, The Petroleum Engineer, November, 1955.*

If the Federal Power Commission approves the Midwestern project, and the two other applications, 2022 more miles of pipe line will be added to the ever-growing TGT network. . . . **a grand total of 11,309 miles for one company and its subsidiary!**

The Canadian Picture

The Midwestern proposal would go far to aid the often-stalled Canadian gas pipe line problem.

Alberta's Premier E. C. Manning has estimated that the gas reserves of Western Canada now total 15.6 trillion cubic feet, and predicts that they may reach 60 trillion in the next 25 years.

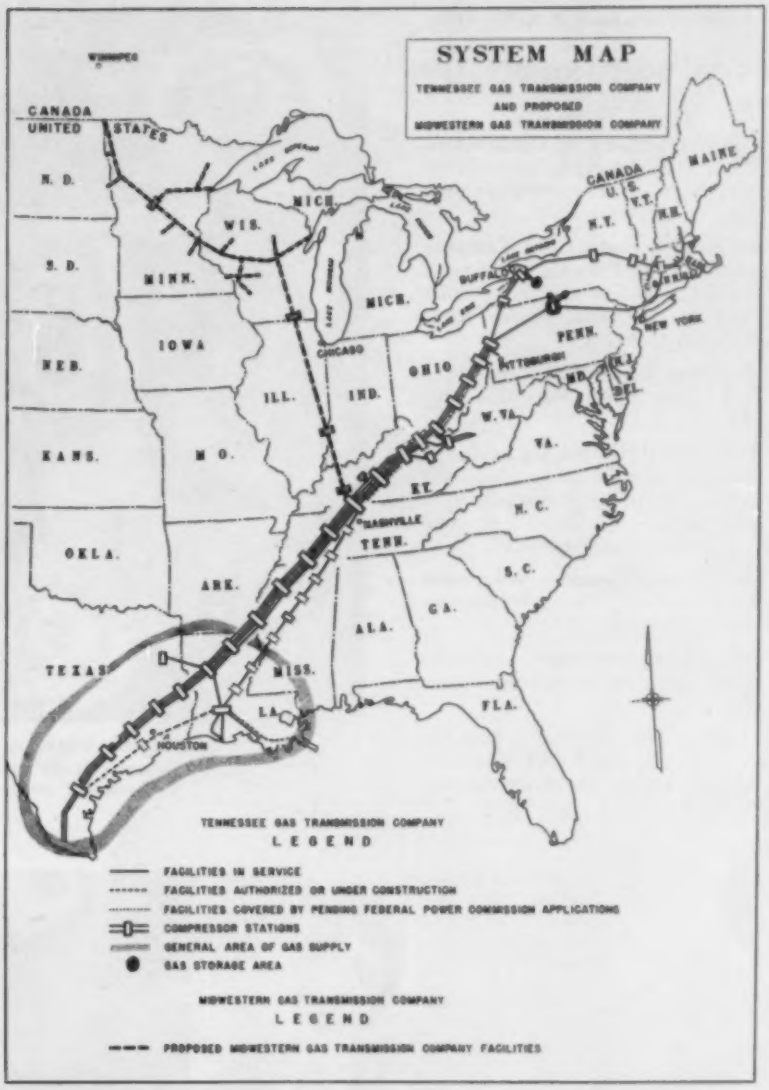
This is considerably more than Canada will use, and the premier is urging that oil and gas companies find a way to pipe gas to U. S. markets as well as eastern Canadian markets.

Because gas that must be produced along with oil cannot now be marketed, the exploration and drilling in western Canada is being hampered. For this reason, the Hudson's Bay Oil and Gas Company and one other major oil company (which has not publicly disclosed its interest) have joined TGT in rendering financial and other aid to Trans-Canada. If the FPC approves the Midwestern system, construction of the Canadian line will move into high gear. And western Canada will at least have an outlet for these fast growing gas reserves.

East-West Exchange

The two companies — Trans-Canada and TGT — have an interchange agreement that will in effect let Trans-Canada develop markets in eastern Canada even before its system spans the country. TGT will take Canadian gas for its midwestern U. S. markets and in turn, supply gas to Trans-Canada to build up the Montreal area market and other eastern Canadian markets pending completion of the 2200-mile Canadian system.

This also means that there will be facilities whereby Canadian gas can actually find its way into the eastern seaboard area.



Completion of its scheduled program, plus proposed expansion, if FPC approves will give Tennessee Gas and its subsidiary, Midwestern Gas, 11,309 miles of pipe lines.

New Coastal Line

Meanwhile, TGT is rolling through Texas again, laying the 30-in. Agua Dulce-Kinder line on a route that edges close enough to the Gulf Coast to give the company easy access to both shoreline and offshore gas supplies.

Construction of this line was kicked off in early September and is scheduled to wind up shortly. The most difficult problems throughout its construction stemmed from water. TGTers call it the "wettest inch" ever built by their company.

The line makes nine — count 'em — major water crossings. These include Lavaca Bay near Port Lavaca, Texas, the Houston Ship Channel, Cedar Bayou, and the Trinity, Neches, Guadalupe, Colorado, Brazos, and Sabine rivers. The bay crossing is the longest on the TGT system — 29,000 ft.

Guadalupe An "Easy Pull"

One of the most interesting features of the job was the crossing of the Guadalupe River and adjacent swamp. The entire 21,819 ft distance was dredged and the pipe was welded into 4000-ft sections for launching.

Launching was made over Collins Construction Company's rubber-tired launchways. The remarkable thing about this is that the entire section of pipe—which weighed 512 lb per lineal foot — could be pulled through the water by a 25-hp outboard motor boat.

Some of the more interesting features on the Agua Dulce-Kinder line construction are shown on the following pages.

CONTRACTORS ON THE AGUA DULCE-KINDER LINE

Associated Pipe Line Constructors, Inc.—Trinity, Neches, Sabine River crossings and the Lavaca Bay Crossing.

Houston Construction Company and the H. C. Price Co. — 96 miles from the Brazos river to 5 miles west of Beaumont. Brazos River Crossing included.

Morrison Constructors, Inc. — 93 miles from Agua Dulce to Lavaca Bay.

Panama-Williams Company—Houston Ship Channel crossing and some underwater construction in San Jacinto and Tabbs Bay. Also Cedar Bayou crossing .

N. A. Saigh Company and Collins Construction Co. — Guadalupe River Crossing.

Western Constructors — 81 miles from Beaumont to Kinder, Louisiana.

WIliams Bros — 73-miles from Lavaca Bay to the Brazos River. Included is Colorado River crossing.

TOUGH GOING through the mud on eastern end of A-K line. Rain was biggest delaying factor in the swampy coastal lands. Contractors called it "racehorse" working country when dry, "miserable" when wet.

TRACTOR HOLDS "WRENCH" on pipe line. This wrench-like clamp keeps the pipe from flopping over due to weight of pontoons on top as pipe moves down launchway.

LAUNCHWAY FOR A MILE of concrete coated 30-in. pipe line. Note the smooth appearance of the concrete coating that gave the pipe a weight of 512 lb per lineal ft and 115 lb negative buoyancy in fresh water.

V-TYPE ENGINES

Nordberg *Supairthermal* V-type engines are built with 10, 12, 14 and 16 cylinders, offering a range up to 5000 hp per engine . . . for Diesel, Duafuel® or Spark-Ignition Gas operation.

(Illustrated is a typical 12-cylinder, 2650 hp *Supairthermal* V-type Diesel engine in pipe line service.)

NORDBERG *Supairthermal*® ENGINES

the logical choice for

PIPE LINE POWER

● On today's modern pipe lines, the trend is toward Nordberg *Supairthermal* engine power. The reasons are simple and sound . . . these compact engines produce *more* power in *less* space—substantially reducing installation and operating costs. What's more—the efficiency of these powerful engines turns low fuel consumption rates into *profit dollars* at the end of the line.

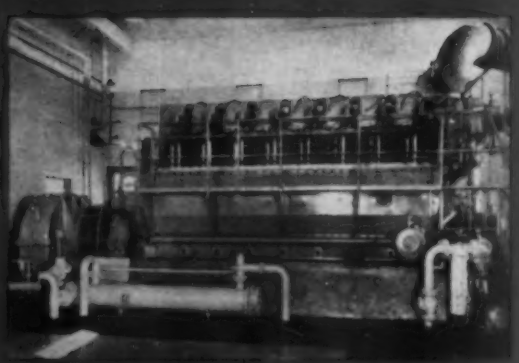
Hundreds of Nordberg engines are daily furnishing continuous, dependable pipe line power in a wide variety of installations . . . from pumping and generating units in permanent trunk line stations, to self-contained portable units for production pumping. Evidence that you will benefit by discussing your power problems with experienced Nordberg engineers.

NORDBERG MFG. CO.
Milwaukee, Wisconsin, U.S.A.

IN-LINE ENGINES

Nordberg *Supairthermal* IN-LINE engines are built in 9" and 13" bore sizes, developing from 535 horsepower upwards . . . for Diesel, Duafuel® or Spark-Ignition Gas operation.

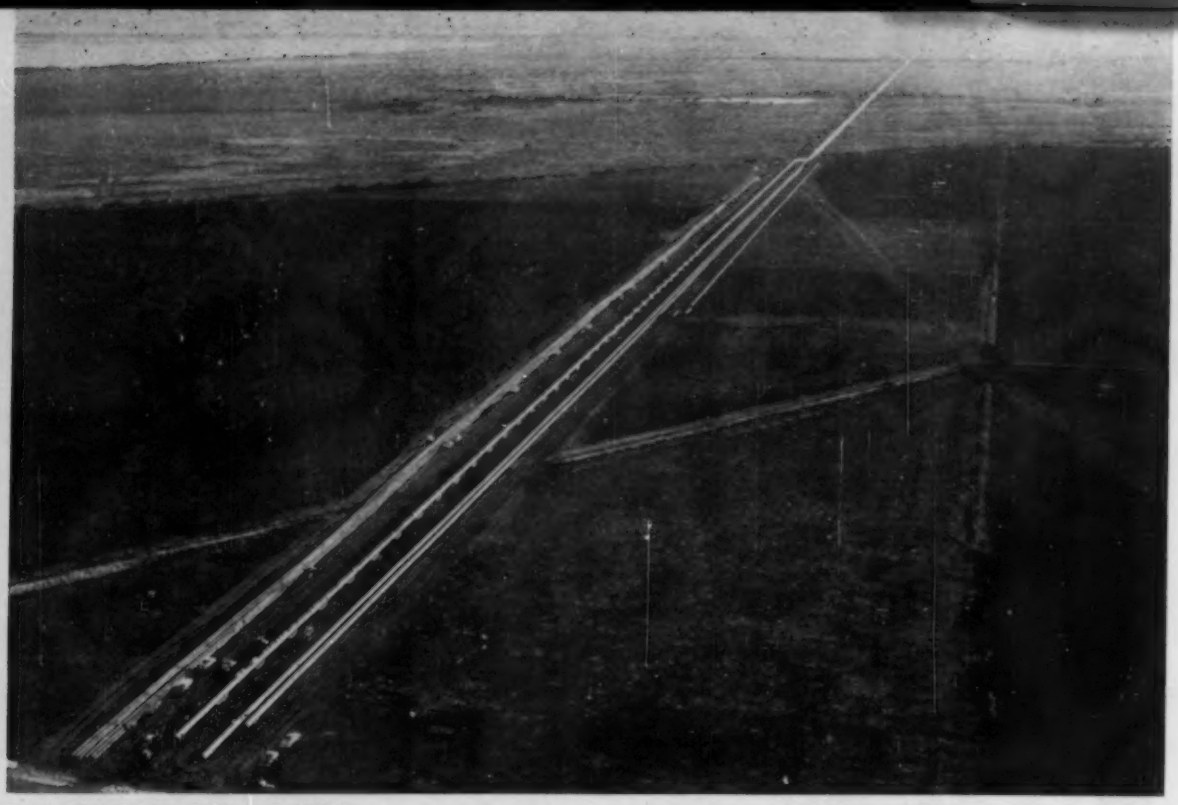
(Illustrated is a typical 8-cylinder, 13" bore *Supairthermal* Spark-Ignition Gas engine operating on a large products pipe line.)



NORDBERG

DIESEL • DUAFUEL® AND SPARK-IGNITION GAS ENGINES

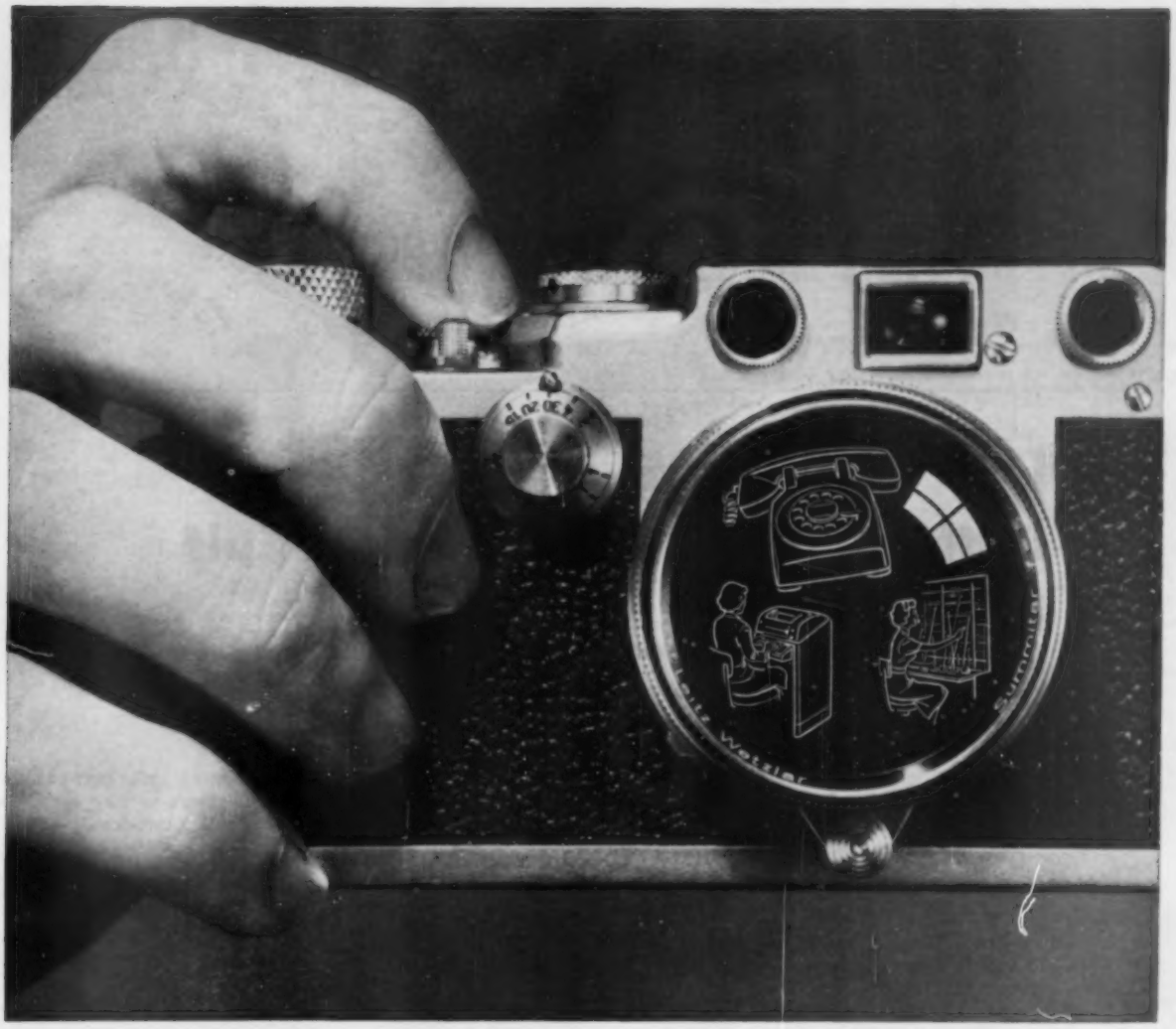
© 1955, Nordberg Mfg. Co. O455



21,819-FT GUADALUPE CROSSING launched 4000 ft at a time. To lay this wide crossing in short order, N. A. Saigh Company used Collins Construction Company launchways, pontoons, and equipment.

COWBOY WATCHES as pipe line eases into the pipe line canal. Once the line was in place, pontoons were released and "herded" back to shore.

MOTORBOAT PULLS LINE through water. A 25-hp outboard motorboat provided adequate power to pull the line over the rubber-tired launchways once pipe started moving.



Do you have a good picture of what Bell System communications can do for you?

Looked at your communications recently? You might be surprised at what has happened as your business has grown—the wrong type of equipment here, not enough of the right kind there.

To make sure your communications are doing a good job for you, why not let the Bell System review them? The result can mean substantial savings in time and money to you, faster and better service for your customers.

Bell System recommendations are "custom-built" for your particular communication requirements. This is important since no two companies, even in the same industry, do business exactly alike. They differ in size, territory and methods of operation.

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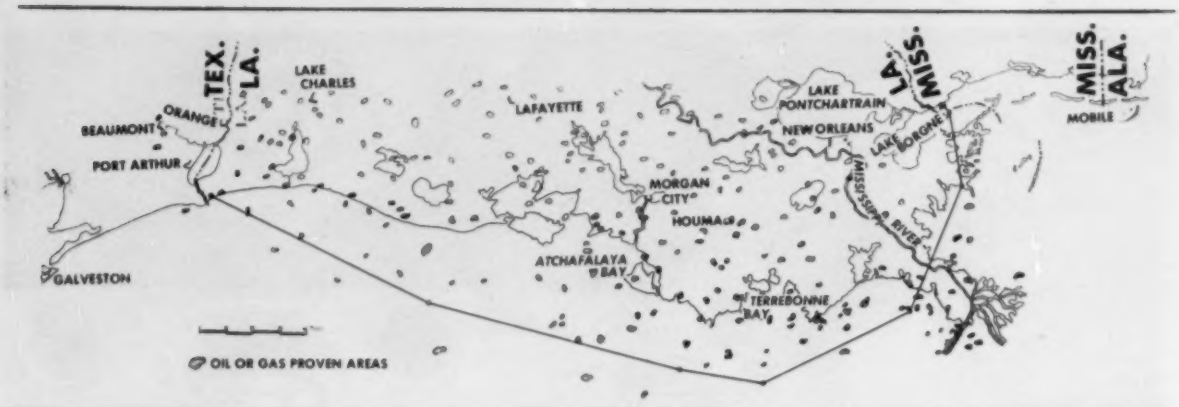
The Bell System will give you a clear picture of your communications and recommend services for your specific needs. There's no cost or obligation—just call your Bell Telephone representative.

BELL TELEPHONE SYSTEM

TELEPHONE TELETYPEWRITER MOBILE RADIO TELEMETERING AND REMOTE CONTROL CHANNELS



Twin 364-Mile Underwater Lines For Both Oil, Gas Planned for Gulf

Donald M. Taylor
Gulf Coast Editor

$157,000,000 project that could "open up" offshore development is now before FPC

F the Federal Power Commission approves, the Offshore Gathering Corporation of Houston, Texas, will lay two 364-mile pipe lines in the Gulf of Mexico. The two lines will run parallel, about 800 ft apart, from Sabine Pass eastward — at a distance of about 25 miles off the Louisiana coast — cutting across the Lower Mississippi River Delta and on to land again just east of the Pearl River in Mississippi. Water depth averages will vary from 40 to 60 ft where the line will lay in the Gulf.

One of the lines will be a 20-in. crude oil carrier, the other a 30-in. gas transmission line. The smaller line is estimated to cost about $51,000,000, the larger one $96,500,000. This is about three times the cost of equivalent lines on land.

This sounds like a lot of money; but, if laid, the lines will split the fairway of the blue chip oil area. Already some $1 billion has been spent on leases, bonuses, exploration, drilling, and production in the Louisiana offshore area, and the number one topic discussed by oil men operating in this section of the continental shelf is **how to get the oil and gas to shore.**

Outlet Lack Causes Shut-Ins

Because of the difficulty in getting gas to shore, many gas wells are shut in today, and paradoxically, this very fact may be the biggest obstacle that Offshore will have to overcome to get permission to pipe the gas to shore.

In a number of fields where operators have found gas they have closed off the well, waiting until a pipe line is available before continuing their drilling development. To the FPC, gas reserves of a one-well field mean little or nothing. Yet, Offshore must show sufficient reserves to get the required FPC approval in order to build the line.

Interior Study May Help

In this regard, Offshore is banking heavily on FPC's acceptance of figures set up for the area by the Department of Interior. According to Secretary of the Interior Douglas McKay, the government estimates the offshore reserve potential to be 63 trillion cu ft of gas, which is in excess of a seven-year supply of gas for the entire United States.

Whether or not FPC will accept the figures of another government agency remains to be seen.

Should FPC not approve the gas line, the crude line will not be laid, as the two necessarily work hand-in-glove. Nearly all wells in the area produce a high volume of gas along with the crude and distillates and flaring of gas to produce the oil is frowned upon by government and producer alike.

Crude Line to Flow Both Ways

The crude oil line is designed to deliver at both ends. It will transport its cargo to the Beaumont-Port Arthur refining area and to similar areas near New Orleans. Possibly an extension from the Mississippi shore may be built by other companies to take crude to eastern or northern refineries.

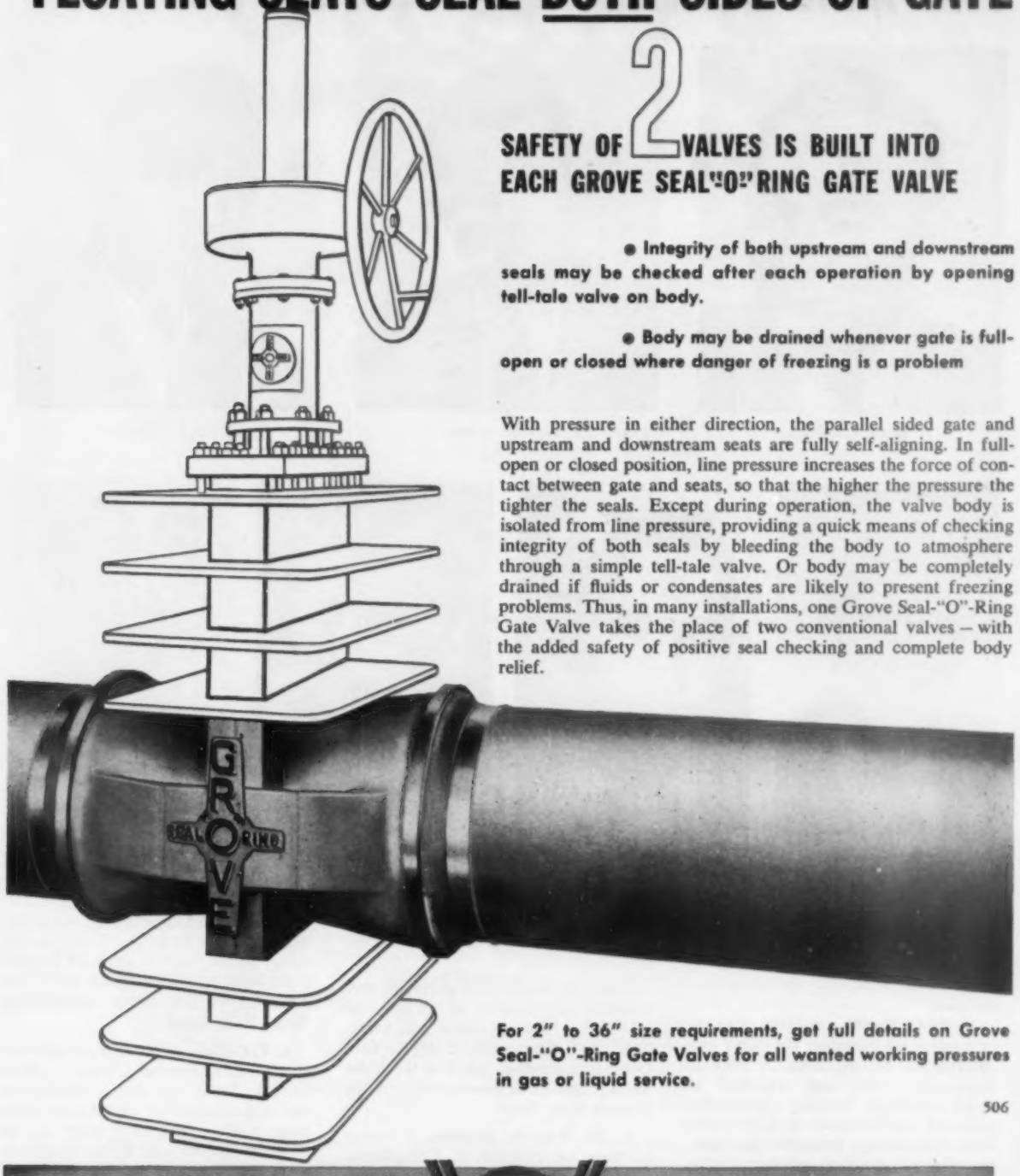
Project Favored by Producers

There are several reasons why some of the major oil companies favor the project. One is that nearness of an existing pipe line can sometimes determine whether an oil field is commercial. In several instances, fields have been abandoned because small reserves would not justify laying a pipe line to shore. But if a pipe line ran nearby, the field could be economically produced.

An executive of one of the major offshore producers favors the project because, as he puts it, "The cost of laying a pipe line from a field to shore is by no means the only expense involved. There is still the expense of laying lines across swamps, lakes, and marshes of South Louisiana in order to tie in to an existing line to transport the oil to a refining or tanker-loading facility. We would like to see such a line laid, and might even participate in the venture financially."

To date, Offshore has revealed but little of its engineering planning, save for the line sizes and the fact that sufficient laterals will be laid to eliminate the necessity of hot tap on one of the main lines. A liquid petroleum recovery plant would be constructed at an estimate cost of $9,800,000 and if volumes are sufficient to warrant it, compressor stations will be constructed both onshore and offshore.

FLOATING SEATS SEAL BOTH SIDES OF GATE



SAFETY OF 2 VALVES IS BUILT INTO EACH GROVE SEAL-"O"-RING GATE VALVE

- **Integrity of both upstream and downstream seals may be checked after each operation by opening tell-tale valve on body.**

- **Body may be drained whenever gate is full-open or closed where danger of freezing is a problem**

With pressure in either direction, the parallel sided gate and upstream and downstream seats are fully self-aligning. In full-open or closed position, line pressure increases the force of contact between gate and seats, so that the higher the pressure the tighter the seals. Except during operation, the valve body is isolated from line pressure, providing a quick means of checking integrity of both seals by bleeding the body to atmosphere through a simple tell-tale valve. Or body may be completely drained if fluids or condensates are likely to present freezing problems. Thus, in many installations, one Grove Seal-"O"-Ring Gate Valve takes the place of two conventional valves – with the added safety of positive seal checking and complete body relief.

For 2" to 36" size requirements, get full details on Grove Seal-"O"-Ring Gate Valves for all wanted working pressures in gas or liquid service.

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GROVE SEAL RING GROVE SIMPLICITY ACCURACY SAFETY

THE MEN BEHIND THE PROJECT

David C. Bintliff

Jack G. Taylor

David T. Searls

E. O. Bennett

John H. Williams

S. V. Collins

Harry J. Mosser

An important aspect of the Offshore Gathering Corporation's proposed plans is the stature and substance of the team of men who are behind the company:

David C. Bintliff, president, is an independent oil operator; organizer and incorporator of Associated Oil and Gas Company; owner and organizer of three mortgage banking companies; treasurer and director of Gulf-Canal Lines, Inc., a barge transportation company; owns important real estate holdings in Houston, San Antonio, San Angelo, and Lafayette, Louisiana; owns three cattle ranches.

Jack G. Taylor, executive vice president, is asociated with the David C. Bintliff Interests as executive assistant to Bintliff; is president of the Commercial National Insurance Company and vice president of the three mortgage banking companies and Trans-Tex Production Company. Was formerly endowment officer of the University of Texas and associate professor at the university.

David T. Searls, vice president and secretary, is a member of the law firm of Vinson, Elkins, Weems and Searls (Houston); director of Oil Center Tool Company; director of Ben Franklin Savings and Loan Association and the Almeda State Bank.

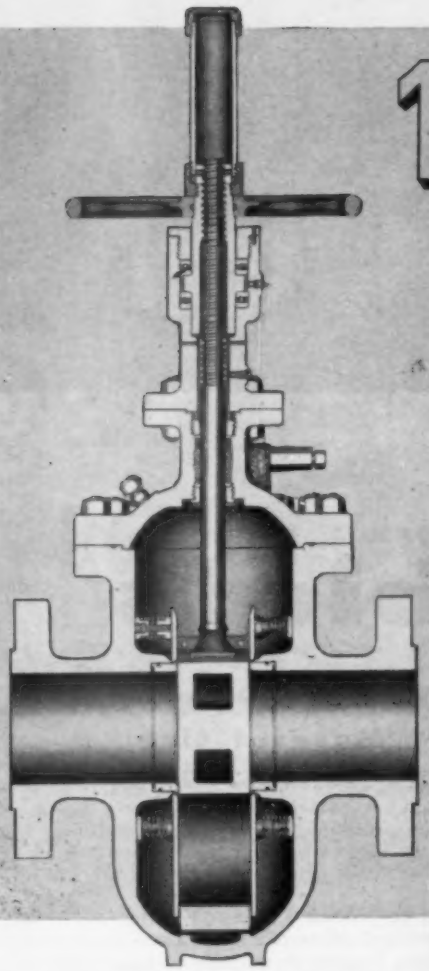
E. O. Bennett, director, is senior partner of Petroleum Consultants, Houston engineering firm. Was prominent in the organization of Texas-Illinois Natural Gas Pipe Line Corp. Did much of the original work in what is now the Trans-Canada Pipe Line Co. Before forming the consulting firm that he now heads, Bennett was chief engineer of Continental Oil Company.

Harry J. Mosser, director, oilman and banker, is president of Associated Oil and Gas Co., H. J. Mosser Oil Co., and South-Tex Corporation; vice president of Alice Bank and Trust Co. of Alice, Texas, and director of Empire State Bank of Dallas, Texas Bank and Trust Co. of Sweetwater, and the San Diego State Bank.

S. V. Collins, director, is president of Collins Construction Company, Port Lavaca, Texas. His firm specializes in the construction of underwater pipe lines. Collins personally takes charge of these projects and he has figured in some tough ones all over the globe.

John H. Williams, director, is president of Williams Brothers Company, Tulsa, Oklahoma, one of the world's foremost pipe line construction firms. His organization has built, or participated in the building, of some of the most important pipe lines in the U. S. and foreign countries. Williams also is treasurer of the Pipe Line Contractors Association. ★ ★ ★

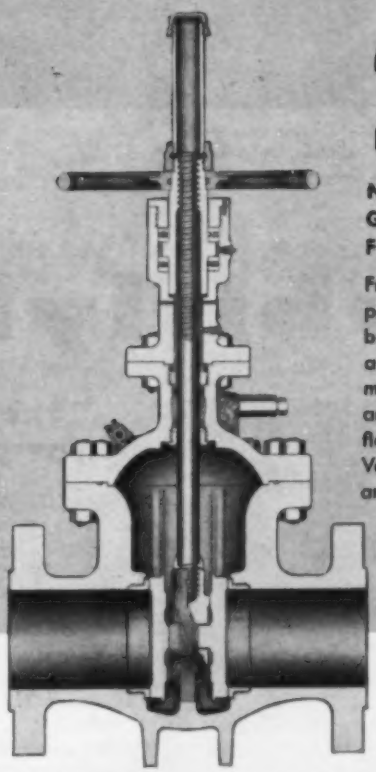
CRANE
Announces Two New
PIPE LINE VALVES



1

NEW CONDUIT-TYPE GATE VALVE
ONE-PIECE DISC; NON-DIRECTIONAL FLOW

Bottom seated, "O" ring-sealed seat rings are self-aligning, and self-sealing on closure—one-piece conduit-type disc uses line pressure for tight seating, does not need excessive stem thrust—spring loaded disc plates prevent loss of grease and entrance of line dirt into body. Sizes, 2 to 30-inch, full-way; venturi patterns also available.



2

NEW DOUBLE DISC GATE VALVE WITH FREE-TO-ROTATE DISCS

Free-to-rotate discs distribute wear, prolong life—machined guides in body accurately control disc clearances—annular wedging surfaces maintain perfect disc alignment and compensate for any body deflections imposed by line strains. Valve operation is easier, surer, and maintenance is greatly reduced. Sizes, 4 to 24-inch.

BOTH LINES OF VALVES HAVE bolted "O" ring-sealed bonnet-joint; 2-piece bonnet and yoke; fully enclosed yoke for stem thread protection and lubrication; plastic packing with injector-check valve; supporting legs cast on body; pressure relief valves.

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HIGH ABOVE THE TALL SWAMP GRASS a surveyor takes a sight, flanked by helicopters front and rear. High platforms, which fold up easily for transport on the 'copters, provide a clear view.

P 615.

whirlybirds

Speed Surveying on TGT'S "Muskrat Line"

IN AND OUT OF SWAMP AND MARSH crews are moved quickly by the darting 'copters that can land almost anywhere in the South Louisiana country.

EVERY phase of building a pipe line through the watery world of muskrats and alligators in South Louisiana is a rough and tough business. Possibly the toughest job is surveying. The surveyors are the fellows who have to open up the new "vistas."

But surveying crews on Tennessee Gas Transmission Company's new "Muskrat Line" have found the going a lot easier than usual . . . thanks to the "whirlybirds." Helicopters, it seems, have added a new measure of speed to their surveying operations.

Ideal for transportation in South Louisiana's marshlands, the helicopters can land on a "postage stamp" on dry earth or water. Even in jungle-choked areas, they can deliver men close to their work by setting down on the many bayous that cross the areas.

The 'copters are not only useful for transportation purposes, but are also being used to pull 1000-ft measurement chains from stake to stake through the marshes.

Using boats, two survey crews formerly could cover only

Through Mountainous Terrain, Dust Storms and Weather Extremes...

From a point on Colorado's Cheyenne Mountain, the microwave beam is relayed over mountains and prairies alike in its 230-mile swing to gas fields in Kansas and Oklahoma.

RCA Microwave's Dependability

has justified Colorado Interstate Gas Co.'s choice for pipeline communications system

When Colorado Interstate engineers studied communication facilities to connect home office with pipeline compressor stations and with gas-producing fields in Kansas and Oklahoma, they considered wire line, common carrier and microwave. They chose RCA Microwave.

According to W. I. Blount, Superintendent of Dispatching and Communications, "RCA Microwave offered many advantages. It provided relatively easy maintenance, static-free operation and was economically equal to wire line or common carrier. And the more numerous the channels, the cheaper by comparison it became.

"In addition, such a microwave system made it possible to integrate into our already established VHF radio system more stations and mobile units and thus increase the efficiency and scope of our radio system. It offered almost unlimited future possibilities, such as telemetering channels, facsimile, teletype, additional voice channels, remote control of unattended stations and a service channel—all at a relatively small cost."

Only RCA MICROWAVE systems provide so many advanced engineering features. For example, single sideband suppressed-carrier frequency-division multiplex is used exclusively to meet high standards of dependability. Frequency is controlled from the terminal through the entire system.

Microwave specialists will be glad to answer any questions and plan your installation. Mail coupon for further particulars on use of Microwave in utilities, pipelines, turnpike and other applications.

RCA MICROWAVE

POINT-TO-POINT COMMUNICATION

RADIO CORPORATION of AMERICA
COMMUNICATIONS EQUIPMENT
CAMDEN, N. J.

Radio Corporation of America
Communications Equipment, Dept. A-127, Building 15-1, Camden, N. J.

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NAME _____ TITLE _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

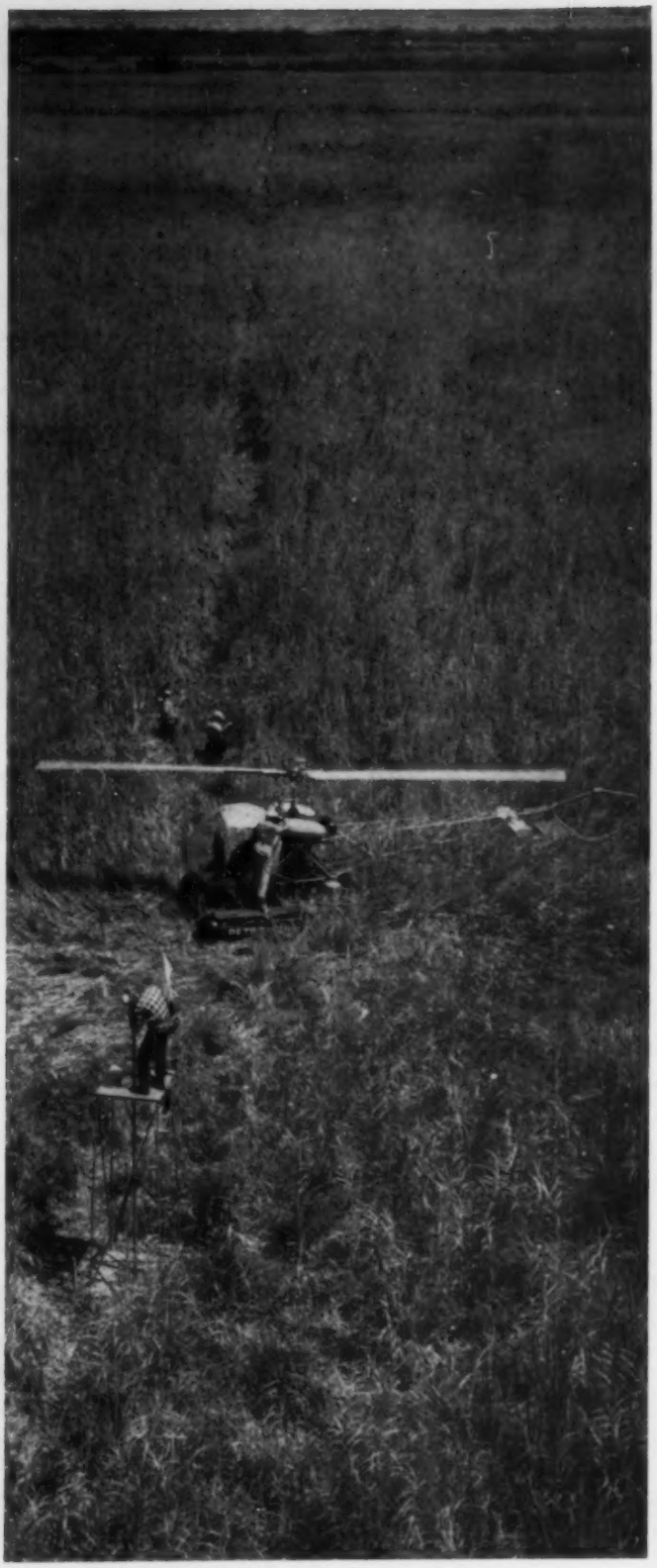
☐ Have an RCA Representative get in touch with me.

ON THE BAYOU. Helicopters deliver surveyors and equipment to points of easy access to the new pipe line route.

about a half-mile per day. Riding helicopters, they are covering five miles every day.

The line being surveyed is a new 355-mile, 6 through 24-in. gathering system for TGT from a point on its present Bayou Sale pipe line through the low-lying country of southeast Louisiana to the very mouth of the Mississippi River on the Gulf of Mexico. Practically the entire length of the line will be concrete-coated to hold the pipe in the marshy earth. ★ ★ ★

EVERYTHING'S BUILT FOR SPEED of operation. Surveying equipment is lightweight and for movement, is lashed to the helicopter's landing pontoons.



PRIMITIVE PATHWAY through the grass-choked swamp land of South Louisiana will soon hum with sounds of a new activity—pipe line construction crews. First signs of the new line are the hand-hacked routes.

EACH year an overwhelming majority of pipeline owners and operators select *coal tar* coatings to protect their long-term investment. And with good reason: No other material can match coal tar coating's *proven* record of economical, long-lasting protection.

Coal tar coatings are amazingly durable. And their life is measured in decades—thanks to their inherent ability to resist soil stress and water absorption, the two big reasons why other materials fail.

If you'd like to be sure of the *best* pipeline protection that money can buy, specify *Pitt Chem* Coal Tar Coatings, just as scores of leading pipeline companies do. When you buy *Pitt Chem*, you buy *assured* pipeline protection with every drum, because *Pitt Chem* Coal Tar Coatings are manufactured to rigid, *published* specifications by a basic producer. If *you* have a pipeline protection problem, chances are we have the answer. *A phone call will place an experienced Pitt Chem man at your service.*

PITT CHEM® TAR BASE COATINGS

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EXCLUSIVE

Completion of Butte's System Gives Eastern Montana Its

First Oil Pipe Line Outlet

Frank H. Love
Editor, Oil and Gas Pipelining

RECENT completion of the Butte Pipe Line Company system will give a distinct boost to drilling development in the Williston Basin, particularly eastern Montana, which it provides with its first crude oil pipe line outlet.

Heretofore, oil produced in the Poplar, Richey, Glendive, Gas City, Pine, Cabin Creek, Pennel, and Little Beaver fields had been transported by truck or tank car as their only means of reaching market. Now, this 506-mile pipe line system, which originates in the Poplar field, Montana, and connect with existing pipe lines at Fort Laramie and Guernsey, Wyoming, provides an immediate outlet for 37,000 bbl a day and an ultimate outlet of 70,000 bbl a day.

The system is owned by Shell Oil Company, Murphy Corporation, Placid Oil Company, and Northwestern Improvement, with Shell as the majority stockholder the operator.

The system consists of 10-in. pipe from Poplar to Glendive, Montana, 12-in. from that point to Baker, Montana, and 16-in. from Baker to the terminals at Fort Laramie and Guernsey. A combination 10 and 12-in., 28-mile line connects the Pine field to the mainline at Baker, and a 6-in., 20-mile extends from Baker to the Little Beaver field.

Crude transported by the Butte system is received in shippers' facilities at seven injection stations.

At the Guernsey, Wyoming, terminal deliveries are made to Platte Pipe Line Company for movement to Wood River, Illinois, and to Continental Pipe Line Company for movement to Denver, Colorado. At Fort Laramie, Wyoming, terminal Service Pipe Line Company takes the crude for transportation to Chicago and Wood River.

Initial capacity of 37,000 bbl per day is with two mainline pumping stations, based on 100 SUS viscosity, 0.85 specific gravity crude, and 100 per cent load factor. The ulimate capacity of 70,000 bbl a day will be with three stations.

Construction Problems

A varied terrain is traversed by the line, from prairie land to mountainous. An unusual feature is the fact that the line is uphill over almost its entire route, from 2020 ft at Poplar to 5100 ft near Fort Laramie.

The ditch was made with conventional ditching machines and to a depth that provided a minimum 3 ft cover. Before the pipe was lowered in a 15-ft section of pipe was dragged along the bottom of the ditch to give it the proper curvature to fit the pipe. Through rocky areas the bottom of the ditch was padded with 6-in. of backfill free of hard objects.

Coating, other than that used on road casings and river crossing pipe, consisted of one coat of enamel, a single wrap of glass fiber reinforcing, and one wrap of 8-lb impregnated asbestos felt. Welds were spot checked by X-ray.

Mainline route of Butte Pipe Line Company's Montana-Wyoming system.

Three major river crossings were made, the Missouri (1964 ft), Yellowstone (2594 ft), and the North Platte (955 ft). These lengths include channel width and approaches. Actual channel widths are as follows: Missouri 493 ft; Yellowstone 553 ft, and North Platte 650 ft. The crossings were prepared by dredge and dragline. Pipe used in the crossings has a ½-in. wall thickness and was coated with three layers of enamel and three wraps of glass fiber reinforcing.

Pipe Mileages and Sizes

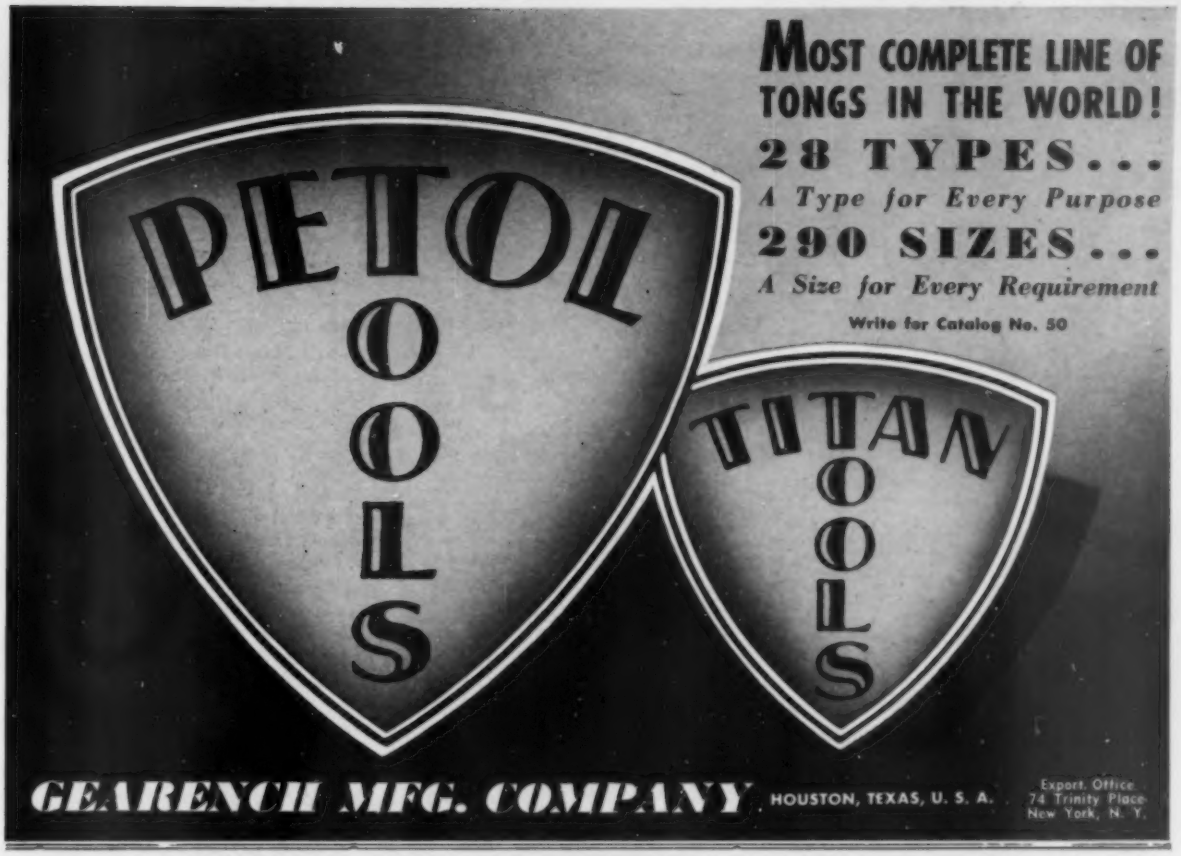
These are the pipe mileages and sizes:

Poplar to Fort Laramie and Guernsey, approximately 84 miles of 10¾-in. OD, 53 miles 12¾-in. OD, and 312 miles of 16-in. OD.

Approximately 2.6 miles of 12¾-in. and 23.5 miles of 10¾-in. were used in the Pine-Baker line.

Approximately 31 miles of 6-in. went into the Little Beaver- Baker line.

The 10¾-in. pipe was delivered in 40-ft random lengths and double random lengths. There were 83.41 miles



The recognized superlative performance of the Cleveland Model 320 Trencher was further improved during 1955 by the addition of the following features: increased width capacity (52 inches)—heavier rims and buckets (¾ inch hi-tensile steel)—crawler kick-out clutch—added conveyor-discharge length and height. Get the complete dope on these new features of the "320" and on other Cleveland Trenchers and Backfillers from your local distributor now.

THE CLEVELAND TRENCHER COMPANY, 20100 St. Clair Avenue, Cleveland 17, Ohio

Pipe for a creek crossing, made up into a single section, is walked into place by sideboom tractors.

Coating and wrapping machine takes a steep grade without even slowing down.

of the 40-ft pipe, 5LX-46 seamless, with 0.250-in. wall and weighing 28.04 lb per foot; 23.55 miles of double random length 5L-Grade B seamless having a wall thickness of 0.279 in. and weighing 31.44 lb per foot; 0.004 mile of 5LX-42 seamless having 0.365-in. wall, weighing 40.5 lb per foot, and 0.476 mile of 53B seamless with 0.5-in. wall and weighing 54.7 lb per foot. The last was used on the Missouri River crossing.

The 12¾-in. pipe consisted of 53.92 miles of 5LX-52 electric weld, 0.250-in. wall, 33.38 lb per ft; 1.36 miles 5LX-42 seamless, 0.375-in. wall, weighing 49.60 per foot, and 0.48 mile seamless, 0.5-in. wall, weighing 65.40 lb per foot. The last was for the Yellowstone River crossing.

Of the 16-in. pipe there were 311.59 miles of 5LX-52 seamless, double random length, 0.250-in. wall, weighing 42.05 lb per foot; 0.604 mile 5LX-42 seamless, 0.375-in. wall, weighing 62.60 lb per foot.

A total of 30.67 miles of 6-in. pipe was used, all on the Little Beaver-Baker lateral. This was seamless pipe having a 0.250-in. wall thickness and weighing 17.02 lb per ft.

Station Construction and Equipment

Mainline stations are at Baker, Montana, and Osage, Wyoming. At Baker station pumping equipment consists of one single-stage centrifugal pump driven by a 300-hp, 3600-rpm, 2300-volt, 3-phase, 60-cycle squirrel cage induction motor, and three 3-stage centrifugal pumps driven by 500-hp, 3600-rpm, 2300-volt, 3-phase, 60-cycle squirrel cage induction motors.

At Osage station there are one single-stage centrifugal pump driven by a 300-hp motor and two three-stage centrifugals driven by 500-hp motors.

Both stations are equipped with electrical control and switchgear for sequence starting of the motor-driven pumps; pressure and flow transmitters; flow controllers, and diaphragm control valves.

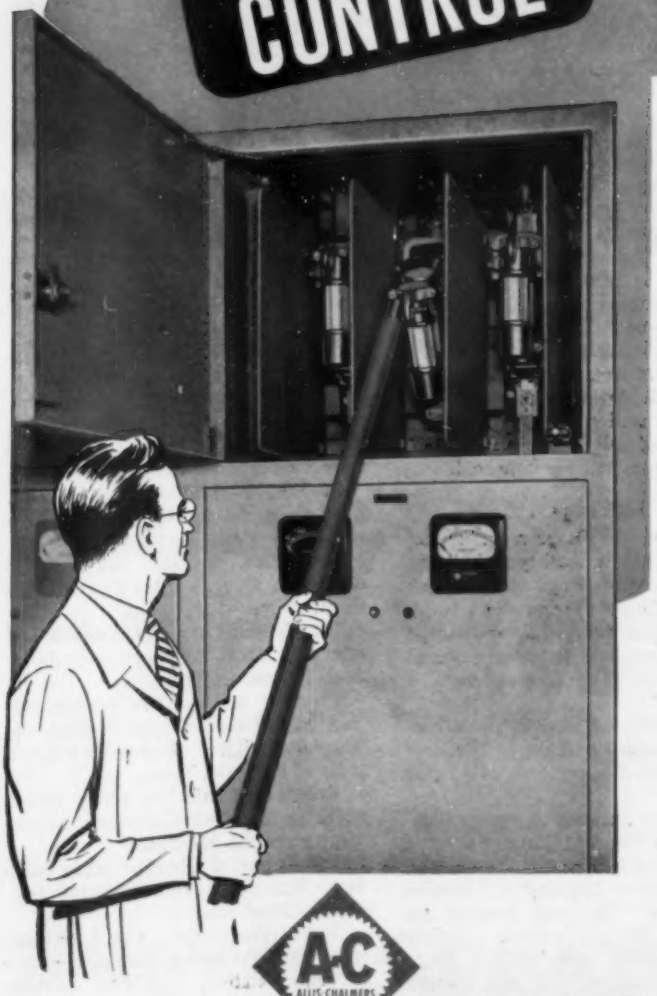
Through-conduit gate valves are used at scraper traps and station block valves. Double-disk gate valves are used for station manifold, tank manifold, and tank valves in sizes of 16-in. or smaller and at ratings of 150 to 600 psi. Both motor and gear operated types were installed.

Pumphouse construction is of prefabricated steel framework, with corrugated asbestos roof and sides, flat transite interior walls and ceilings, concrete floors, except for the operating room where vinyl asbestos floor tile is used.

The pumphouse is L-shaped, having the pumproom on one side and switch-

What is your Control Need?

MOTOR CONTROL



. . . a starter for a fractional hp motor?

This small inexpensive control provides thermal overload protection. . . . Compact construction permits mounting where space is at a premium. Designed for use on ac single-phase power systems . . . up to 230 volts.

. . . a controller for a 2300 to 5000-volt motor?

Here is a control for motors up to 2500 horsepower. All components — contactors, meters, overload relays, auxiliary switches — are selected to meet the particular requirements of your application. Current-limiting fuses give split cycle short circuit protection.

. . . or other applications?

Specific applications, including those between the above-mentioned limits, are made from an extensive line of starters and control components. These standard units are factory assembled in infinite combinations to meet practically any requirement. For help on a particular application, call your Allis-Chalmers representative. His recommendations are backed by Allis-Chalmers engineering departments . . . by experience gained solving thousands of control problems . . . by complete research and testing facilities.

A-4721

A-C ALLIS-CHALMERS

ALLIS-CHALMERS

Milwaukee 1, Wisconsin

Conventional type machines made the ditch; pipe was given a minimum 3-ft cover.

gear, boiler room, and shop on the other. The operating room connects the two segments and is pressurized, whereas a slight vacuum is maintained in the pumproom. The walls and ceilings of the pumphouse are insulated with 3 in. of glass fiber, and the building heated by a low pressure steam system, the steam being provided by a 20-hp boiler.

At the Baker station two 30,000-bbl and two 40,000-bbl tanks have been provided.

Injection Stations

Injection stations are situated at Poplar, Glendive, Gas City, Pipe, Cabin Creek, Little Beaver, and Pennel.

The Poplar injection station has two pumping units with suction lines connected to two 20,000-bbl tanks owned by the Murphy Corporation. Pumping units consist of one 2½ by 5½ by 10 reciprocating duplex piston pump, V-belt driven by a 75-hp motor, and one 4 by 7¼ by 12 reciprocating duplex piston pump, V-belt driven by a 200-hp motor.

Glendive injection station has truck unloading facilities and two pumping units, with suction lines to Butte's 5000-bbl tank, The Texas Company's two 5000-bbl tanks, and Shell Oil Company's 1000-bbl tank. These pumping units are 4 by 7½ by 10 reciprocating duplex piston pumps, V-belt driven by 100-hp motors.

Pine injection station also has two 4 by 7½ by 10 reciprocating duplex piston pumps, one driven by a 75-hp motor, the other by a 100-hp motor. Three 10,000-bbl tanks at this location are owned by Shell.

Cabin Creek has a single 4 by 7½ by 10 reciprocating duplex piston pump driven through a V-belt by a 50-hp motor. Suction lines connect with two 5000-bbl tanks owned by Shell.

Gas City has the same size and type of pump as Cabin Creek, but it is driven by a 105-hp internal-combustion engine. Suction is from one 5000-bbl tank and one 1000-bbl tank, the property of Shell.

Pennel station has a 2½ by 5 by 10 reciprocating duplex power pump driven by a 40-hp motor, taking suction from a 1000-bbl and a 5000-bbl tank, owned by Shell.

At Little Beaver is installed a 2½ by 4 by 6 reciprocating duplex piston power pump V-belt driven by a 25-hp gas engine. Shell Oil owns four 1000-bbl tanks at this location.

Pumping units at all injection stations are skid-mounted for ease of moving if events demand that this be done. Each station also is provided with low-level tank cutoff controls for automatic shutdown of pumps.

Injection station pumphouses are prefrabricated galvanized iron on steel frame buildings and are unheated.

Auxiliary Buildings

The Baker and Osage mainline stations each has a steel-type building used as a two-car garage and storage.

At Fort Laramie the auxiliary building is equipped with a shop and garage and is of prefabricated steel covered with asbestos. The shop portion is heated.

A prefabricated steel-frame-galvanized-iron-covered building at Glendive houses a small shop and switchgear equipment.

At all injection stations except Glendive, Gas City, and Little Beaver a small building has been erected similar to the auxiliary building at Glendive to serve as office and housing for switchgear. Offices in these buildings are insulated and heated.

A prefabricated steel and asbestos covered building at Laramie Junction serves as an office and also houses a sample laboratory, locker and utility room. Floors are finished with vinyl asbestos tile and walls and ceilings with flat transite.

A wooden frame office building with asbestos shingle siding and asphalt shingle roof was constructed at Glendive for use of gaging personnel and the district superintendent. In addition to office space, the building houses a sample laboratory, storage and rest room facilities.

Cottages

Eight cottages were constructed for operating personnel, one at Poplar, Montana, one at Baker station, four in the town of Baker, Montana, and two at Osage station. The cottages are frame, having asbestos siding, asphalt roofs, two bedrooms, living room, dining room, kitchen, bath, large basement containing playroom and utility room, central heat, and attached garage.

Major Contractors

Installation of Section 1 (123 miles), Guernsey to Wyoming State Highway No. 203. Associated Pipe Line Contractors, Inc., of Houston, Texas. (Subcontracted to Engineers Limited Pipeline Company.)

Installation of Section 2 (101 miles), State Highway No. 203 to State Highway No. 212. Associated Pipe Line Contractors, Inc., of Houston, Texas (Subcontracted to Engineers Limited Pipeline Company.)

Installation of Section 3 (102 miles), State Highway No. 212 to Cabin Creek injection station. O. R. Burden Construction Corporation of Tulsa, Oklahoma.

Installation of Section 4 (88.4 miles), south bank of Yellowstone River to Poplar Station. Anderson Brothers Corporation of Houston, Texas.

Installation of Pine-Baker 10-12-in. Line. O. R. Burden Construction Corporation.

Installation of Little Beaver-Baker 6-in. Line. O. R. Burden Construction Corporation.

Installation of stations (mainline and injection). Delta Engineering Corporation of Houston, Texas.

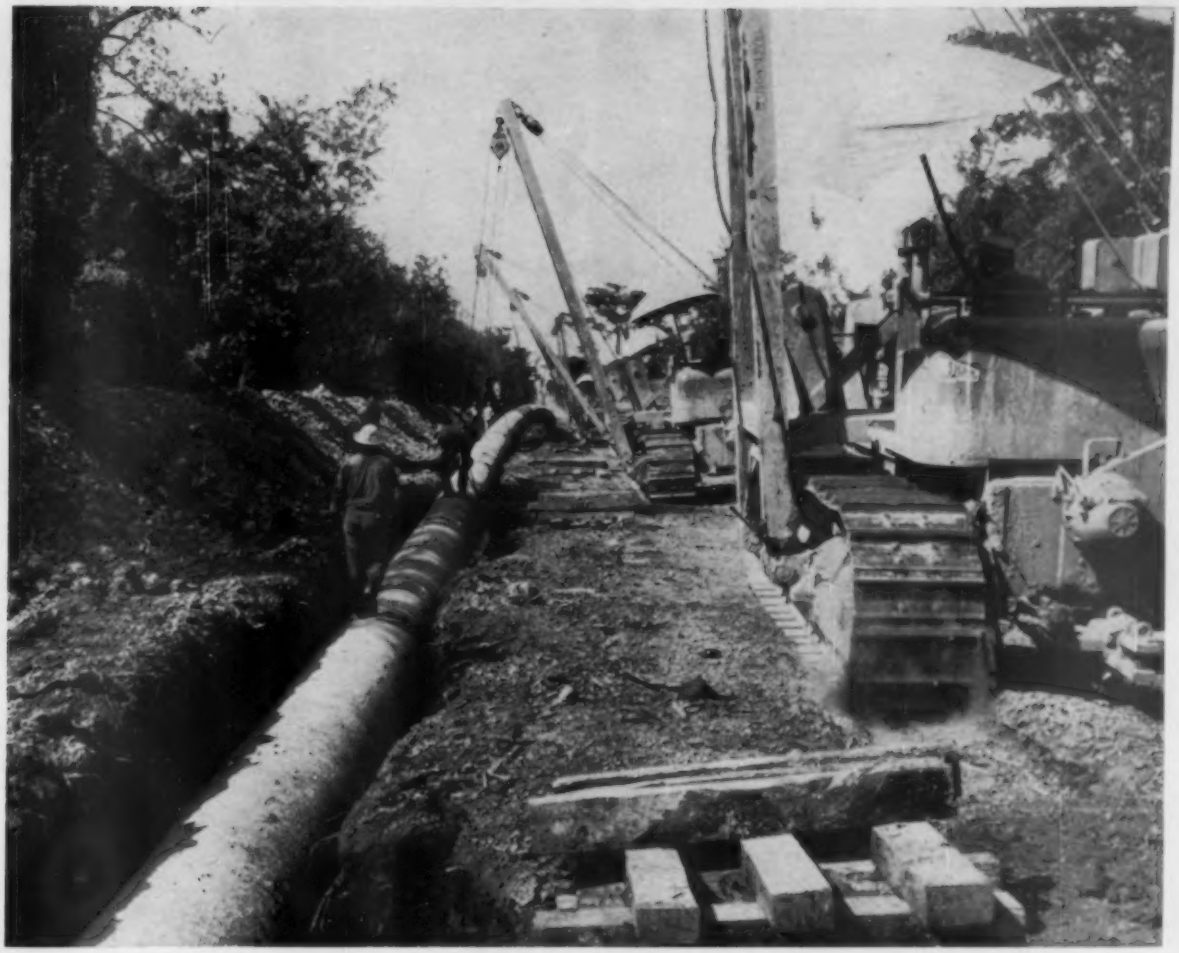
Erection of mainline pumphouses and Fort Laramie gagers office and auxiliary building. Rogers Steel Company of Houston, Texas.

Erection of injection pump station buildings. Jacobsen Construction Company of Froid, Montana.

Installation of Glendive office building. Whitmor Homebuilders, Inc., Tulsa, Oklahoma.

Installation of Butte Pipe Line Company tanks at Baker station, Glendive injection station, and Fort Laramie terminal. Chicago Bridge and Iron Company.

Installation of cottages. Whitmor Homebuilders, Inc. ★ ★ ★



Lowering in Concrete-Coated 30-inch pipe on a recent job in Louisiana. Five HD-20 Sidebooms were used to lower this 22,000 lbs. per joint pipe into the ditch.

Pipelines don't come too big or too little for Grayco Constructors

No matter what the size of the pipe, Grayco Constructors have a backlog of experience that stands them — and you — in good stead. No matter where the job is, Grayco Constructors are ready to take it on — whether it's in the swamps or the arctic.

GRAYCO CONSTRUCTORS, Inc.

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HOME OFFICE • 1211 WEST 34TH STREET • AUSTIN, TEXAS

In the field . . . or at the shop . . . dealers and owners have a big stake in each other's success.

Modern Equipment Maintenance
One of a Series

Behind the dealer's service is a tremendous investment in shop, equipment, parts, personnel; too little recognition has been given

Dealer-Owner Relationships

N. Kent

EQUIPMENT owners and dealers are blood brothers—one could not operate effectively without the other. It is readily evident that the dealer is entirely dependent upon customer, but the part the former plays in the success of the equipment owner may not be as obvious. Let's take a look at this relationship.

As a good number of dealers come from the user's fraternity, or have spent many years in the equipment business, they have a sound understanding of owner's needs and problems. Of course, the dealer helps the customer analyze his equipment needs and assists in the selection of the type and size of equipment best suited for a particular job, but this is far from being as simple as it sounds. Such ability does not come automatically with his franchise as a dealer. Preparation to provide such assistance is, in itself, an expensive, time consuming proposition that he gladly accepts, for he has more at stake than a warm handshake, a car, and five dollar briefcase. He is a reputable businessman whose success depends upon the year in and year out success of his customers. It's no one-shot proposition.

To prepare for the role he assumes, the dealer finances a place of business with all the necessary office fixtures, parts bins, shop tools and equipment, stocks of machines and parts, competent personnel, and many miscellaneous items too numerous to enumerate. All this is necessary as preparation for serving customers—and he must be able to serve customers if he is to succeed. At this point, before he has solicited a machine sale, sold a capscrew, or lifted a wrench, he has invested several hundred thousand dollars toward his customers' success. (The established heavy equipment dealer is capitalized at a net worth of over $1,000,000.)

Even then, he has to mold personnel to intelligently recognize customers' needs, appreciate their requirements, and offer good sound guidance. This takes valuable time, individual and collective effort, and expensive training in the dealer organization, at factory sponsored schools, and good practical experience in the field.

In addition to guidance concerning equipment, dealers are often called upon to help customers line up work as well as establish sound credit standings. The last few years, in particular, have plunged dealers into intimate associations with tax matters, with the result that many customers seek them out for

EXCLUSIVE

Here the HD-21 brings the line up to highway crossing. Complete tractor spread includes two new Allis-Chalmers HD-21's and 13 other Allis-Chalmers crawlers

Pipelining between the highlines

Allis-Chalmers Tractors lay 30-in. line on high tension right-of-way for Contracting and Material Company

Putting down a 30-in. gas line in trench only a few feet from high tension line towers is tough and tricky — but Contracting and Material Company, Evanston, Illinois, made it look easy with their Allis-Chalmers torque converter crawler tractors. The job, located in the outskirts of Joliet, Illinois, called for precision maneuvering, and the 39-ton Allis-Chalmers tractor-boom combinations moved around those steel towers with the ease and agility of a lightweight.

Torque converter tractors work as coordinated unit

In putting in this line, which was lowered directly from dope-wrap into the trench, three Allis-Chalmers torque converter crawler tractors, headed by the new HD-21, handled the job. The work involved frequent catch-off and catch-on by the tractors due to the closely spaced highline towers blocking the way. In spite of these obstacles, the three crawlers worked as a smoothly coordinated unit. With proved torque converter drive, they matched speed perfectly with the dope-wrap machine. The self-energizing brakes and easy-handling controls really paid off in the close-quarter maneuvering.

ALLIS-CHALMERS HD-21

204 net engine hp
127,000-lb lifting capacity at 4-ft overhang
78,250-lb tractor and side boom with full counterweight

Whether in close-quarter work or clear sailing on open right-of-way, you can cut costs and speed up operations with an Allis-Chalmers spread. Get full details on the completely new line of crawler tractors and matched equipment. Let your Allis-Chalmers dealer show you the all-new HD-21, HD-16, HD-11 and HD-6. See him now.

CONSTRUCTION MACHINERY DIVISION, MILWAUKEE 1, WISCONSIN

ALLIS-CHALMERS

Around the line she goes. Here the HD-21 catches-off the line and swings around the tower. Shifting is practically eliminated, operator can concentrate on his side-boom work and keep a lookout for the towers.

unofficial consultation on such matters.

Partswise, bin after bin of genuine manufacturer's parts—not "will fits"—are kept in readiness for the owner. These parts are built with the same exacting precision, same quality as those they replace—and they give the same long-lived economical performance. Not just "a part"—but genuine manufacturer's parts based upon good engineering design and backed by sound research, testing, and manufacturing practices. And best of all—for the owner—it's the dealer's money on those shelves.

Although it is understandable that owners may choose to stock certain items in their own parts warehouse, the dealer can be a valued guide in such practices. By keeping stocks down to bare essentials, the owner can take advantage of improved replacement parts and changeovers as they become available and avoid being burdened with superseded parts.

When it comes to mechanical service, the dealer has much to offer. His investment in land, buildings, tools, equipment, and men practically eliminates the owners necessity for tying up money for these purposes and permits him to utilize such facilities to the best advantage.

The factory supplies the dealer with a virtual stream of service literature, films, and information aimed at keeping dealer service personnel abreast of all changes, methods, and modernizations that will provide owners with improved service life on their equipment. Dealers have quick access to new special timesaving tools that will reduce owners' repair costs. The dealer frequently sends men to factory sponsored training courses and service conferences where they received specialized instructions. This is in addition to their own regular service meetings, which are frequently attended by representatives of the factory service organization.

Equipping his service organization with the tools, equipment, and know-how makes possible guaranteed service—good service—at reasonable costs to users. And when a warranty situation arises, he is right there to make a prompt and just settlement.

On the other hand, assuming that a user prefers to maintain his own service shop and crew of mechanics, the dealer stands ready to offer advice, litterature, and maintenance schools. A poor repair job done in an owner's shop invariably blackens the name and reputation of the equipment and the dealer, so it is to the dealer's advantage to see that the job is done right.

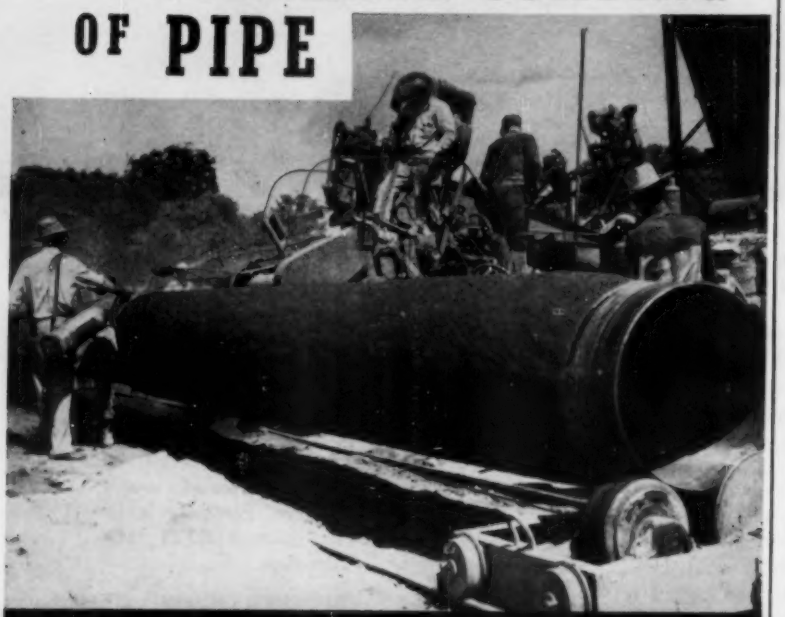
The owner and the dealer have quite a stake in each other's success — and their cooperation is the backbone of the construction industry.

As H. W. Morrison, president of Morrison-Knudsen Company, Inc., said recently in that company's employee publication: "We construction people sometime speak in uncultured slang of the "peddlers" from whom we buy the machinery, tools, and supplies that are indispensable to the conduct of our business. Yet, in a big company like ours, not a day passes when we could do without them." ★ ★ ★

The Author

N. Kent is service manager, plains division of the Caterpillar Tractor Company. Kent joined Caterpillar in 1935 as a machinist apprentice. While working at Peoria, he attended Bradley University and attained an engineering degree and completed three years work in business administration. He entered the service department of Caterpillar in 1946 and was service representative in the southeast until his promotion.

FOR CONCRETE COATING OF PIPE



...on a Production Basis

Half a million pounds a day on 30" pipe is impressive production . . . and that's what ANCHOR-WATE did on a recent job! Concrete coating by men who know from long years of experience, is what you buy at ANCHOR-WATE. It's the dependable answer to pipeline crossings at rivers, on marshy land, etc. If you have a weight problem for crossings, call ANCHOR-WATE.

THE ANCHOR WATE COMPANY

P. O. Box 12185 — 13308 Telephone Road
Phone: MI 9-2769 — Houston 17, Texas

Now you can paint 'em pastel shades . . .

Paint Colors and Their Effect In Reducing Storage Tank Losses

White and aluminum paints are still the most popular colors but don't count out tints of white or tints of aluminum—which have definite psychological values

E. L. Hoffman
Socony Mobil Oil Company,
New York, New York

SINCE its inception the petroleum industry has been faced with the problem of minimizing losses by evaporation of crude and refined products. With the advent of the automobile, the use of gasoline has increased manyfold. Because of its volatile nature, evaporation loss is the major loss experienced in the storage and handling of gasoline. Various types of studies involving tanks and their accessories and operational procedures have been conducted to determine the causes of, and remedies required to reduce, evaporation losses.

The effect of paint color and type on losses also has received, and still is receiving, considerable attention and investigation. For many years our own technicians have been conscious of the values obtained by using white for painting tank roofs. In fact, interest in this matter dates back to 1889, at which time the manufacturing committee advised that whenever tank roofs needed repainting, they should be painted white in order to decrease evaporation losses.

Research on this subject has shown that tests on different colored paints were conducted in the early 1900's. As far as we can determine, the discussion starts with data described in a U. S. Bureau of Mines bulletin on tests made prior to 1917.

Schmidt and Wilhelm,[1] two U. S. Bureau of Mines petroleum engineers, made exhaustive tests on the reduction of evaporation losses in cooperation with the State of Oklahoma, and the results of their tests are frequently quoted in subsequent reports. In one of their tests, five 12,000-gal horizontal tanks were each painted with a different color and tested during 4 summer months. Another 12-month test conducted by this bureau involved four 55,000-bbl crude-oil tanks painted different colors (see Table 1). This test indicated that the black-painted tank lost 649 bbl, whereas the aluminum-painted tank lost only 447 bbl during the test. Another U. S. Bureau of Mines test was made by exposing tanks of various colors to the rays of carbon arcs for 15-min periods and observing the rise in product temperature. Tests were also made on four 55,000-bbl crude-oil tanks covering a period of one year.

TABLE 1. Four 55,000-bbl crude-oil tanks painted black, red, gray, and aluminum.[2]

	Evaporation Loss in one year (barrels)
Black	649
Red	609
Gray	547
Aluminum	447

Phillips Petroleum Company made tests on nine 55,000-bbl tanks covering a 3-month period in the summer of 1936 and again at a later date.

At various times tests have also been made using many other materials in an effort to limit heat input. Such materials included insulation, sun shades when wind conditions permit and, more recently, aluminum shades supported on a cone roof by aluminum trusses. Water sprays and water blankets on the roof have also been used in the past. All of these methods will decrease evaporation losses but, with the possible exception of the aluminum shades, the other devices have generally proved economically unfeasible.

The value of the results of some of the earlier paint tests in particular may be questionable because of the short test period, the small size of containers or tanks, and the methods used in measuring the losses. For example, some tests were made by painting drums of gasoline with various colors, weighing the drums daily, and converting the loss in weight to loss of liquid volume. The preceding examples are cited merely to show the extent of the various tests which have been undertaken, viz., from 50-gal drums to 55,000-bbl tanks, and from 15 min of carbon-arc exposure to periods of one year under natural atmospheric conditions.

As will be seen in the following discussion, however, all test results, regardless of equipment or method, pointed to the same general conclusion

Presented to a meeting of the Division of Marketing's Operations and Engineering Committee during the 35th Annual Meeting of the American Petroleum Inst., in the St. Francis Hotel, San Francisco, Calif., Nov. 14, 1955; original title: "The Effect of Paint Colors in Reducing Storage-Tank Losses."

and, hence, it may be assumed that, in the aggregate, the tests were accurate.

Results On Roof Surface

Cone-Roof Tanks. The historical background indicates that numerous tests have been made on the effect of paint color and type on evaporation losses. This work has been continued from early in the 1900's up to the present time although, except for Smith and Harden, there have been no recent literature reports. Although equipment and methods vary, other phases of the tests usually follow the same general pattern, and the tendency toward error has decreased as the period of the test has been increased.

In one recent test on the relative effectiveness of reflectivity of heat of various types and colors, a mirror or sun-shaded roof gave 100 per cent reflectivity; white paint, 90 per cent reflectivity; whereas black paint showed zero.

A report made in 1950 shows that the loss on a 90-ft by 42-ft tight cone-roof tank which needed painting was 0.33 per cent of the throughput. The same tank with a good white roof experienced a loss of only 0.28 per cent. In terms of gallons of gasoline, this would result in a saving of 10,000 gal annually, assuming the tank had 10 turnovers per year.

A test conducted by H. A. Gardner (see Table 2) to determine the temperature and percentage loss by evaporation was conducted on small tanks of different colors, two-thirds filled with naphtha and exposed to the sun for two hours. The black-painted tank showed a liquid temperature of 110 F with a 9 per cent evaporation loss. A cream tank and a light-blue tank both showed a liquid temperature of 102 F and a 5 per cent evaporation loss, whereas the white-painted tank showed a liquid temperature of 100 F and a 4 per cent evaporation loss.

TABLE 2. Temperature and per cent loss by volatilization in small tanks two-thirds filled with naphtha and exposed to the sun for 2 hours.[23]

Color of Tank	Temperature of Naphtha (Fahrenheit)	Loss of Naphtha by Volatilization (Per Cent)
Black	111	9
Bright red	109	8
Dark green	108	8
Battleship gray	106	6
Tan	104	5
Red primer—white coat	102	5
Cream	102	5
Pale blue	102	5
White	100	4

The white tank was the best, but it is interesting that cream and light blue have only slightly less reflective power. Another test by Gardner has been listed separately in Table 3 because one result in this test differs from the results of all other investigators. Gardner shows liquid-temperature rise in small tanks painted in various colors when subjected to rays of a carbon arc for 15 min. The liquid-temperature rise is 54 F for black, 22.5 F for white, and 20.5 F for aluminum.

TABLE 3. Rise in temperature of benzenes in small tanks painted in various colors (gloss finish), when subjected to rays of carbon arc for 15 min.[24]

Color	Rise in Temperature (Fahrenheit)
Tin plate	19.8
Aluminum	20.5
White	22.5
Light cream	23.5
Light pink	23.7
Light blue	24.3
Light gray	26.3
Dark green	39.9
Black	54.0

The explanation for a lower temperature rise on aluminum than white was given later by Dr. Lotz,[8] who showed that the radiant energy emitted by the carbon arc is of different quality than that received from the sun. Although aluminum shows to advantage in the infrared region, it is definitely less efficient than white when confronted by solar radiant energy.

In an article by J. C. Albright, reported on in Table 4, the brightness of the painted surface before and after weathering is shown in tabular form. White is considerably better than aluminum in the unweathered state and, if a chalking white paint is used, it is also considerably better after weathering. However, white enamel, originally the best, suffers from dirt adherence and, accordingly, reflects even less light than aluminum after the weathering period.

TABLE 4. Brightness of the painted surfaces before and after weathering.[6]

Type of Surface	Unweathered (Per Cent)	Weathered (Per Cent)	Condition of Film after Exposure
White enamel	88	30 to 35	Dirt adhering.
White paint	85	55 to 65	Chalking considerably. Fairly clean on top of tank; dirtier down on sides.
Aluminum paint	56	35 to 40	Dull (appearance— somewhat dirty).
Metallic zinc—powder paint	25	10 to 15	No gloss remaining; slightly dirty.
Black	—	—	Dull appearance; chalking slightly.

Tables 5, 6 and 7 show additional data on reflective properties, and are of interest in that Tables 5 and 6 show that light gray is apparently better than aluminum. Table 8 indicates paint factors applicable to various colored tanks when computing predicted evaporation loss caused by breathing from atmospheric fixed-room tanks.

In addition to the foregoing, when the atmospheric temperature is 85 F, studies show that the vapor-space temperature is about 21 F above the atmosperic for white tanks, but 81 F higher for unpainted tanks. Other studies along a similar line have indicated that the temperature of the vapor in a tank roof painted gray can exceed ambient temperatures by as much as 30 F to 50 F. In the case of the white-roof tank, the liquid temperature was 6 F less than the atmospheric temperature whereas, for the unpainted tank, the liquid temperature was 3 F higher than atmospheric.

TABLE 5. "Reflection values" of several paint colors.*

	(Per Cent)
White	84
Light gray	53.6
Aluminum	41.9
Black	1.12

* Light reflection efficiency determined by Munsell Color Co., Baltimore, Md.

TABLE 6. The approximate reflecting power to solar radiation of various colors of paints applied on smooth surfaces.[10]

Color	Radiation		Maximum Btu Absorbed Per Square Foot Per Hour during August in 40-Deg Latitude
	Reflected (Per Cent)	Absorbed (Per Cent)	
White	84	16	50
Light gray	54	46	143
Aluminum	42	58	180
Black	1	99	307

TABLE 7. Relative effectiveness of paints in keeping tanks from warming in the sun (white is 90 and black is 0).[20]

	Average relative effectiveness as reflector or rejector of heat
Soot	7.5
Black	0.
Red (bright)	17.2
No paint	10.0
Red (dark)	21.3
Aluminum (weathered)	35.5
Gray	47.
Gray (light)	57.
Aluminum	59.2
Aluminum (new)	67.0
Cream or pale blue	72.8
Green (light)	78.5
Gray (glossy)	81.0
Blue (light)	85.
Pink (light)	86.5
Cream (light)	88.5
White	90.
Tin plate	97.5
Mirror or sun shaded	100.

TABLE 8. Approximate paint factor applicable to various colored paints when computing predicted evaporation loss caused by breathing from atmospheric fixed-roof tanks.[12]

	Good Paint
Insulation	1.0
White	1.0
Light Gray	1.1
Aluminum	1.2
Yellow brown	1.25
Red or black	1.5
No paint	—

In the preceding I have indicated results obtained from the literature to show extremes in variations. The data are tabulated in the appendix to this report. In a review of over 20 articles on the subject of light-colored paints for storage tanks, all but one of the reports show that certain light-colored paints applied to the roof had a marked influence on the reduction of evaporation losses. The important thought developed is that, by reducing the variations of the temperature of the air-va-

por mixture in a storage tank, a resultant decrease in evaporation loss can be achieved.

The reason that light-colored paints reduce evaporation losses is that, because of their reflectivity, they reduce the variations of the temperature of the vapor space. In addition, the actual temperature of the vapor is lowered, and the surface temperature of the oil is decreased. This not only reduces the amount of the air-vapor mixture breathed by the tank, but it results in a decreased amount of gasoline vapor in the air-vapor mixture above the oil. White paint provides the best reflection of heat and reduces the evaporation losses to the lowest percentage. It is also of interest, as indicated in some of the tables in the appendix, that some of the lighter pastel colors such as cream, light yellow, and light blue have reflectivity characteristics which are almost as good as white.

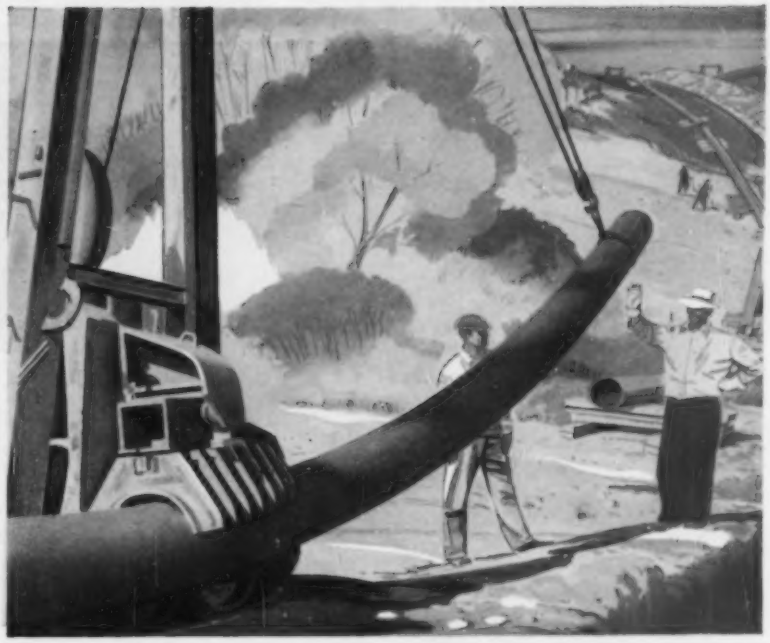
Accordingly, a substantial reduction in losses can be achieved by using a paint having good reflection and one which maintains this reflectivity over a long period of time. It is essential that this whiteness must be maintained for a long period, and this is obtained through self-cleansing of the paint by what is best described as "controlled chalking." This quality in a reflective paint will be discussed later at greater length.

The data presented in the appendix in the first 7 tables are, for all practical purposes, summarized in Table 9. Table 9 is a resume presented in an API Symposium on Evaporation Loss report in Chicago in 1952. The table, which is applicable to tank shell as well as tank roof, indicates the relative importance which various oil companies place on reflective values for different paints. The table indicates that the use of suitable white paint will reduce breathing losses to 75 per cent of those experienced with aluminum paint and 60 per cent of those experienced with an unpainted roof.

TABLE 9. Paint factors involved in breathing-loss calculations for gasoline from cone-roof tanks, shown in the API Symposium on Evaporation Loss, November 10, 1952 (Factors are for roof and shell paint as stated).[25]

Aluminum weathered	1.00
White, chalking	0.75
Light gray	1.10
Black, no paint or needs repainting	1.25

It is fair to assume that the data used by the oil companies were, in turn, developed from available literature and from their own research. Although additional concentrated research might show these values to be slightly in error, there is no longer any question but that white roofs are a good investment and result in excellent payouts for



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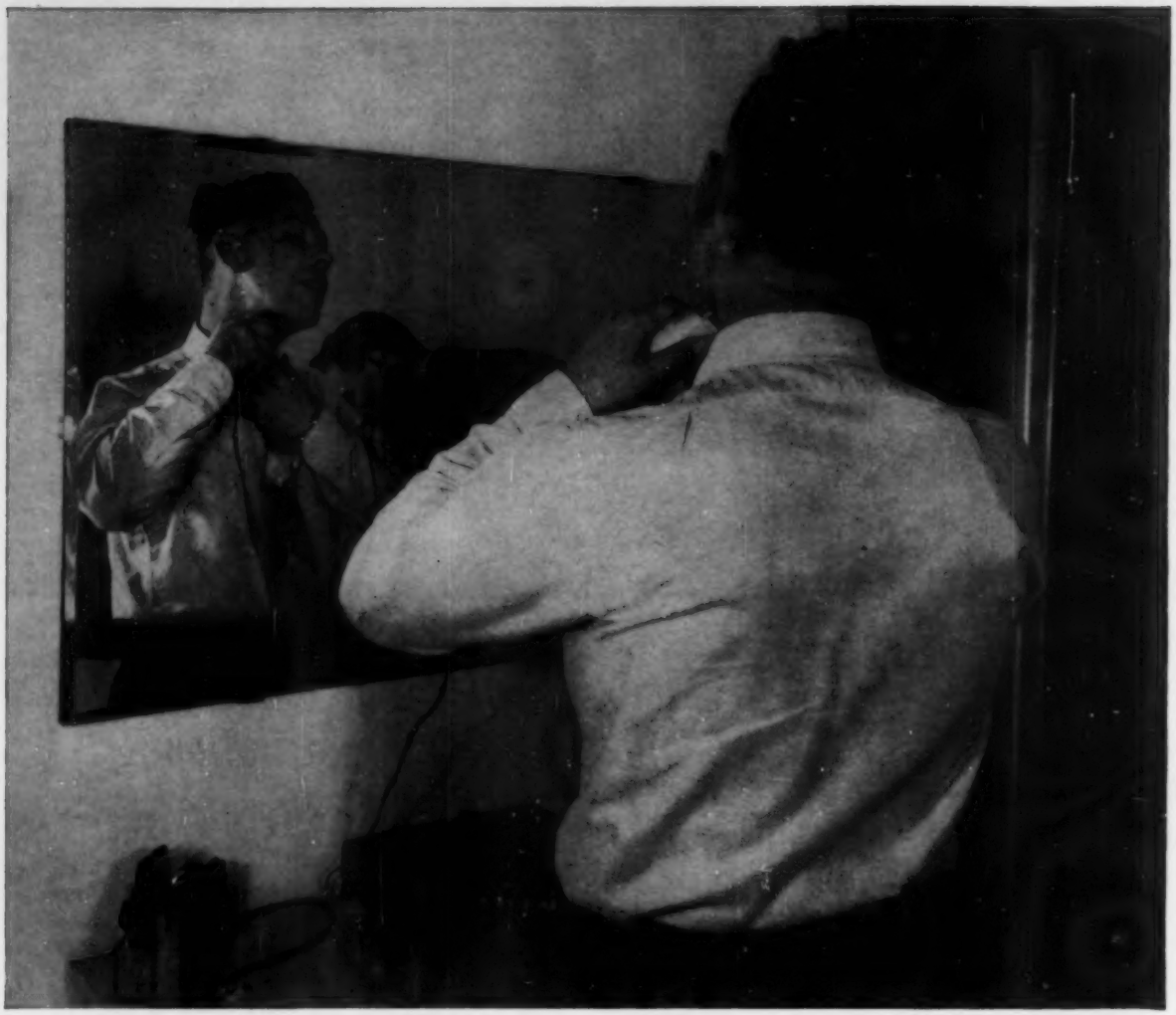

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atmospheric fixed-roof or cone-roof tanks.

Conservation-Type Tanks. Whenever conservation tanks are considered, however, a different problem is encountered. These tanks may be considered in two categories for the purposes of this paper:

a. Variable-vapor-space tanks: As the name implies, these tanks — including the wet-seal lifters, the dry-seal lifters, and the flexible-diaphragm tanks — all have a variable-volume vapor space.

b. Floating-roof tanks. The essential difference in operation and evaporation losses in the foregoing two categories is that variable-vapor-space tanks are designed essentially to obtain almost complete elimination of breathing losses but only a slight reduction in throughput or filling losses. Accordingly, they are usually found in those bulk terminals in which the annual turnover is usually less than six times the capacity.

Conversely, floating-roof tanks are designed to eliminate filling losses and do sustain some breathing losses. These tanks are usually found in refineries and large bulk terminals and, in general, will have an annual throughput of 10 or more times the tank capacity. In regard to the color to be used in painting these tanks, it is apparent that, if white paint is used on the variable-vapor-space tanks, there would be a reduction in vapor temperature.

Because of their construction, white paint will more effectively reduce vapor temperatures in these tanks than in cone-roof tanks. Although the saving in breathing loss on these tanks, in spite of the reduced temperature, is not as great as in cone-roof tanks, there is still an attractive payout because of increased capacity and slightly reduced filling losses. Accordingly, it is recommended that a slow-chalking white paint be used for these roofs. On the floating-roof tanks, although white paint would be of some value in reducing breathing losses, it is not recommended because it is impossible to use self-cleansing chalking white paint. This is so because, if such a paint were used, the chalked paint and adhering dirt could not be carried away effectively.

Results on Tank Shell

Cone-Roof Tanks. Although considerable work has been done over the years on tank-roof paint, no great stress was placed on the color of the shell of the tank, apparently because it was felt that the color of the roof paint was the most important factor affecting evaporation losses. Further, inasmuch as the tank-roof area was considerably less than the shell and was more easily repainted, the greater frequency of repainting was not particularly objectionable from a cost standpoint.

In regard to the shell of the tank, it was originally considered advisable to use a dark paint primarily to extend the period between repainting and to avoid erecting expensive staging. The earliest tank-shell colors were black and dark red, and these eventually gave way to shades of gray. Gray was used for many years, although today to a large extent, it has given way to aluminum paint because aluminum is durable and, except when compared with white, it does have a good solar-heat reflectivity.

Smith and Harden, in a study reported upon at the Products Pipe Line Technology Conference in April 1952,[16] showed that, in their opinion, it was even more important to have the shell white than the roof white and that the greatest effect was obtained by painting both roof and shell white. The apparent reason for this is the extreme difference in the heat conductivity between the liquid phase and the vapor phase. Further, although an aluminum roof will result in a higher temperature directly under the roof, the heated vapor will act as an insulation keeping the other vapor in the tank relatively cool.

In the case of a white roof the vapor directly under the roof is cooled by the convection currents set up by the shell and causes complete mixing, so that the average temperature in the vapor phase is actually higher with a white roof and aluminum shell. The average liquid temperature is several degrees higher for a white roof and aluminum shell than for an aluminum roof and white shell. The majority of the Smith and Harden data was obtained either in drums or relatively small tanks. However, it seems reasonable that the data on the drums and small tanks indicated qualitatively, if not quantitatively, the results which would be obtained in larger storage tanks.

Essentially the data showed that energy transmission along a vertical plane, rather than horizontal, accounts for the major portion of the heat energy which is converted to volatile loss from storage. Quoting from Smith and Harden:[16]

> "The effectiveness of the sidewall transmission is a function of high heat transfer coefficients and thermal convection currents, which abet the transfer of available sidewall energy to the two phases of gasoline. This absorption of sidewall energy reduces the stratification of heavy hydrocarbon vapors near the liquid vapor interface and augments the natural breathing and venting of

the tank by the constant readjustment of the liquid's effective vapor pressure. In contrast, the transfer of energy downward from the roof area primarily affects only the thermal expansion characteristics of the vapor, and tends to be self-insulating."

A report was published in *The Oil and Gas Journal*, July 14, 1952.[22] Although the presentation is somewhat different, the conclusions are exactly the same. This article also points out that, in their small-scale tests, the liquid phase absorbs 120 times the available energy absorbed in the vapor space, despite the fact that 60 per cent of the tank surface area is in contact with the vapor space. This relationship would undoubtedly be changed in favor of the vapor space if the normal relationship of diameter to height were used, and if the tests were conducted on a year-round basis instead of just for one of two months.

It was realized that, in order to get the proper quantitive facts, large tanks would have to be used and, accordingly, additional test work was done in two newly painted 80,000-bbl cone-roof tanks, one painted aluminum and the other white. Both tanks were half full of 10.5-lb-RVP motor gasoline. This study was completed in the early fall and again proved that the evaporation losses were proportional to the amount of solar energy absorbed by the liquid and vapor phases of the storage product. The data on this test are given in Table 10.

It was concluded that the transmission of energy responsible for evaporation losses is primarily through the shell of a storage tank.

On these large 80,000-bbl tanks, a conservative estimate of additional losses (aluminum over white) was $1750 per year for motor gasoline. If it is assumed that white paint has half the life of aluminum paint, which is a conservative estimate, and that repainting of white must proceed every 3 years, the cost of an extra coat of white paint every 3 years can be assessed over a 6-year period based on 5 cents per square foot for repainting costs. The additional cost of repainting based on a 120-ft by 40-ft 80,000-bbl tank at 5 cents per square foot is $1320, or $220 per year. Accordingly, for a gross saving of $1750 per year, there is a net saving after deducting additional paint costs of $1530 per year, and a figure of $1500 would seem conservative. The gasoline savings quoted are from the Smith and Harden article,[22] but the data on repainting costs were arrived at independently and constitute our own data presented later in this paper.

The conclusions reached by the American Petroleum Institute at the Symposium on Evaporation Loss previously quoted (see Table 9) are that evaporation losses are reduced 25 per cent provided that the roof and shell of cone-roof tanks are painted white rather than aluminum. Based on the data presented in this paper, the author feels that this is a reasonable conclusion, although for reasons cited later, it may be that the savings would be in the range of 20 per cent to 30 per cent rather than the 25 per cent figure actually used. Another slight advantage in favor of having an all white cone-roof tank is that staining of the shell of the tank, previously noticed with a white roof and an aluminum or gray shell particularly on tanks having inside top angles, will no longer be observed.

The storage of crude oil in cone-roof tanks presents a special problem. If it is assumed that the quality of the crude oil purchased is approximately average, then the color of the cone-roof tank depends on the volatility of the crude oil. Although the following figure represents at best an approximation, depending on ambient temperature and other factors, a Reid vapor pressure of 4.0 lb is a reasonable estimate of the point of division; crude oils with a Reid vapor pressure of 4.0 lb or above should be stored in cone-roof tanks painted white, although the paint color is not significant in the case of crude oils with lower Reid vapor pressure.

It will be difficult to arrive at exact savings on the value of white shell paint in cone-roof tanks storing volatile products unless the following factors, which refer to the Smith and Harden article,[22] are given consideration:

a. No data are given concerning the area of the roof as compared to the height of the tank. In a survey of hundreds of tanks it was proved that only 23 per cent of the total area was roof. Obviously, a tall tank would lend itself to greater heat absorption through the sides, whereas a large, low-framed cone-roof tank would transfer proportionately more heat through the roof.

b. Inasmuch as the work was done on a 50-per-cent-capacity basis, the relatively large vapor phase would present a greater insulating barrier to heat transfer than when the liquid phase increased.

c. There is no indication that any of the tanks which were tested and reported on in the article were working tanks. It can be assumed that, in working tanks, blending of fresh stocks maintains liquid temperature more nearly constant, thereby permitting less influence on the liquid phase by heat transfer through the sides.

d. The picture has apparently been developed for product storage in temperate climates. It is conceivable that in tropical or semitropical areas, the greater amount of vertical solar radiation would enhance the importance of white roofs and decrease the relative importance of white side walls. Moreover, a corrosive atmosphere could modify the conclusion by its effect on paint life.

Conservation-Type Tanks. On the variable-vapor-space tanks previously mentioned, it is believed that present data do not warrant slow-chalking white paint from an evaporation-loss standpoint. The recommended white roof paint, covering a somewhat larger area than on a similar cone-roof tank, is more effective than in the case of the cone-roof tank; and, accordingly, additional savings in breathing losses from shell paint may be disregarded. White shell paint would probably reduce throughput or filling losses slightly because of lower product temperatures, but not nearly enough to warrant the increased cost of painting with white paint.

The floating-roof tanks present a different problem and should be considered in two categories insofar as shell paint is concerned:

a. Old floating-roof tanks or tanks with riveted shells.

b. Newer or welded floating-roof tanks.

In the older floating-roof tanks breathing losses are a matter of some concern particularly when the tank is known to be out-of-round or equipped with a pan-type roof. Losses by breathing in tanks of this nature may exceed those in a cone-roof tank. The potential breathing-loss savings on riveted-shell floating-roof tanks are sufficiently great that a slow-chalking white paint is recommended for the shell. Where crude oil is stored in older

TABLE 10.[22] Evaporation losses in large storage tanks painted aluminum and white respectively.

Quantity Measured	Time Period	New aluminum paint	white paint	Ratio of aluminum to white
Volume of hydrocarbon vapor vented (at 60 F and 760 mm of mercury), cu ft	9/24/51 to 10/ 6/51	193,334	148,010	1.3
Average expansion in vapor phase, per cent	9/24/51 to 10/ 6/51	6.4	4.7	1.4
Average gallonage, gal per 1000 cu ft of vapor	9/25/51 to 10/ 3/51	10.0	7.9	1.3
Gasoline lost as vapor, bbl	9/24/51 to 10/ 6/51	46	28.0	1.6
60-F liquid lost (tank gage), bbl	9/24/51 to 10/ 6/51	76.0	59.0	1.3
Liquid loss during initial time period—heat absorption period, bbl	9/19/51 to 9/23/51	35.0	18.0	1.9
Overall liquid loss, bbl	9/18/51 to 10/ 6/51	110	77.0	1.4
Liquid lost (as determined by Chenicek Whitman apparatus), per cent	9/24/51 to 10/ 6/51	0.266	0.20	1.3

floating-roof tanks, each case must be considered on its own merits.

On the newer floating-roof tanks, including only tanks equipped with welded shells and particularly those having double decks or special devices to minimize breathing losses, white shell paint is not recommended. The reason for this is that breathing losses are only a fraction of those sustained by the comparable cone-roof tank and, accordingly, potential savings are too small to warrant the additional cost of white paint.

Obviously, in both categories of floating-roof tanks there will be some tanks of doubtful classification insofar as breathing loss is concerned. The exact status of these tanks should be determined by a careful inspection of the tank roof, and a careful appraisal made as to the probable breathing losses. If this survey has been made, it will then be possible to recommend the color of paint to be applied to the shell.

Paint—Type, Methods and Costs of Application

Color. As has previously been indicated, the most reflective paint is the white paint, and the exact type of white paint will be described subsequently in greater detail. However, in connection with color you are no doubt aware of the recent trend in oil refineries and marketing terminals toward the use of many colored paints, particularly the pastel shades.

A major oil company has started a program aimed at improving the eye-appeal of their tankage. At a large eastern refinery the shells of many tanks have been painted in pastel colors and, in some cases, the tanks have been painted with two contrasting colors. There are several reasons for this: One is that oil storage tanks are classified by the average motorist as unsightly, and it is hoped that the pastel shades will be more pleasing to the eye and promote better public relations. Another reason is that these pastel colors may have a psychological value as a morale booster insofar as the refinery worker is concerned. This program has also been extended to some of their marketing terminals.

In the case of the refinery tanks there are two color schemes which have been used. In some cases the entire shell has a pastel color whereas, in other cases, a two-tone effect is used involving a dark color on the lower half of the tank and a light color on the upper half. For example, if the lower half is blue, the upper half could be yellow; or the lower half red, and the upper half pink. Some tanks have a solid shell color with a top band of red or blue. Apparently the interest

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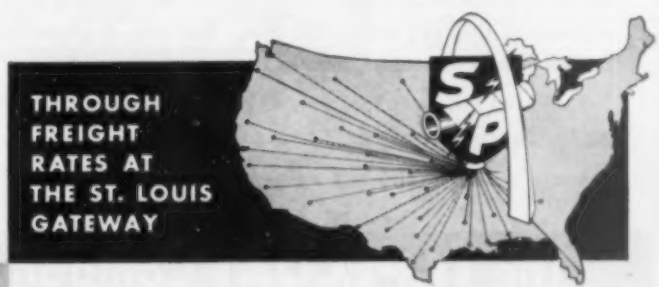

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is more in color contrast than it is in a tank with a solid color on the shell.

As shown in the tables in the appendix, the temperature rise of both vapor and liquid is greater in tanks painted with a color than with a tank painted white. However, it is possible to use a two-tone pastel color combination and still not lose too much from an evaporation-loss standpoint.

For example, if the roof is painted white and the shell is painted cream or light yellow, light blue or light pink, the reflective value of the paint on the shell will be greater than aluminum or gray and, in fact, inferior only to white. Although this would result in a slightly greater loss of volatile products by evaporation than for white paint, this loss would not be great and would be more than counterbalanced by the aesthetic appeal and the improvement in morale. Although these latter factors cannot readily be evaluated in terms of dollars and cents, it is believed in many quarters that they are worth this slight additional expense.

Our own company has experimented with tinted aluminum paint for some time. Do not confuse tinted aluminum with the blue tint added to the first coat of a two-coat aluminum paint job to insure complete coverage of the top coat. These tinted products are for the purpose of adding color to the final aluminum coat. Most of the original experiments were confined to small tanks and test panels to determine the weathering characteristics and permanency in the various colors. Inasmuch as aluminum paint is not recommended for evaporation-loss purposes, as indicated in Table 9, it is obvious that the tinted paint is also not recommended for volatile-product tanks as, for all practical purposes, it has the same reflective value as the base aluminum.

Although aluminum is not recommended for tank shells, it is true that, in many cases, present specifications on volatile-product tanks still indicate white roof coats and aluminum shell coats. The author believes that ultimately most shell specifications on volatile-product tanks will call for white paint. However, pending this time, it should be noted that a diffuse type of ready-mixed aluminum paint is the recommended type. In this paint there is a certain roughness which deflects the sun's rays in all directions, thus providing maximum reflective characteristics. A smooth-surfaced aluminum paint, after weathering, has a tendency to appear dull gray and to reflect the sun's rays from only one angle. The diffuse type of aluminum paint is recommended for shells of volatile-product tanks only where it is essential that aluminum be used in

order to comply with present specifications.

Type. It has been established in the foregoing that white is the most efficient pigment which can be used for high solar reflectivity and consequent minimization of evaporation losses. The ideal white paint for this purpose should not only have a high degree of whiteness, but it should have the ability to maintain this whiteness. Also, it should have a high degree of permanence. This paint will most effectively reduce tank temperatures and show the lowest evaporation loss over the longest practical period of time. A satisfactory tank white paint should:

a. Provide high solar reflectance during the entire life of the film.

b. Provide long life and protection against severe weathering and corrosive refinery or other industrial fumes.

The quality of whiteness is obtained from the pigment. The ideal paint for storage tanks is one in which the pigment particles are packed closely together. This close-packed pattern results in a paint film which has good resistance to soiling and dirt pickup. The preferred pigment is titanium dioxide, which has the highest whiteness of any pigment and is also chemically inert.

It is an established fact that stone, glass, concrete, composition shingles, and the like collect dirt and become dingy and, in industrial areas, become actually black in appearance. In other words, all surfaces which are relatively permanent in nature and show little or no surface decomposition become dirty and unsightly. Paints are no different from other materials in this respect; as their durability is increased and the rate of surface failure retarded, their tendency to collect dirt increases.

When paint soils, its reflective quality approaches that of the adherent dirt film, which is invariably lower than that of the white finish. Therefore, an acceptable tank white paint must be self-cleansing. In the chalking process an extremely fine white powder forms on the surface, which is washed off by rain and wind taking along with it the heat-absorbing grime and dirt.

The vehicle itself adds nothing to whiteness, but acts as a binder for the pigment and bonds the paint to the surface. In this regard, the most durable vehicle for paints is still an alkyd resin or modified glyceryl phthalate. Inasmuch as the vehicle collects and holds dust and may even discolor, the proportion of vehicle in the paint should be low and the quantity — and continuity — of pigment in the dried paint film high.

There is apparent conflict in two desired properties of paint, viz., the ability to maintain brightness and the degree of permanence. Brightness is

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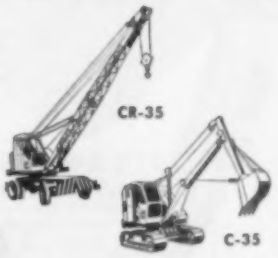

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maintained by suitable composition and proportion of vehicle and pigment, so that a slow and controlled chalking results. A satisfactory paint is designed to delay initial chalking as long as possible for the particular environment to which the tank is exposed. In this manner, the paint remains self-cleansing and yet has reasonably good life.

The rate of surface renewal required to maintain a good brightness on the tank roof will vary with the environment. Whenever terminals are located near chemical plants or in an industrial area, or are subjected to smoke or the effect of fumes and dirt, a comparatively free-chalking special white paint is required. On the other hand, for the vast majority of storage terminals, a slower chalking and consequently more durable white has proved satisfactory.

Frequency of Repainting. Storage tanks containing volatile products are painted not only to reduce evaporation and improve their appearance, but also to counteract the effect of corrosion which shortens the useful life of the tank. It has been estimated that over 1,000,000 gal of paint are consumed every 3 days for corrosion prevention of steel. Much of this quantity is used for this purpose by the petroleum industry. In fact, protection from corrosion and reduced evaporation of products constitute the two most important reasons for application of paint to storage tanks.

In combating corrosion, paint functions principally by means of the following two methods:

a. By sealing off the steel surface from the corrosive environment, i.e., waterproofing and exclusion of oxygen.

b. By pigmentations which alter conditions favoring corrosion, i.e., prevent transmission of electrolytic currents.

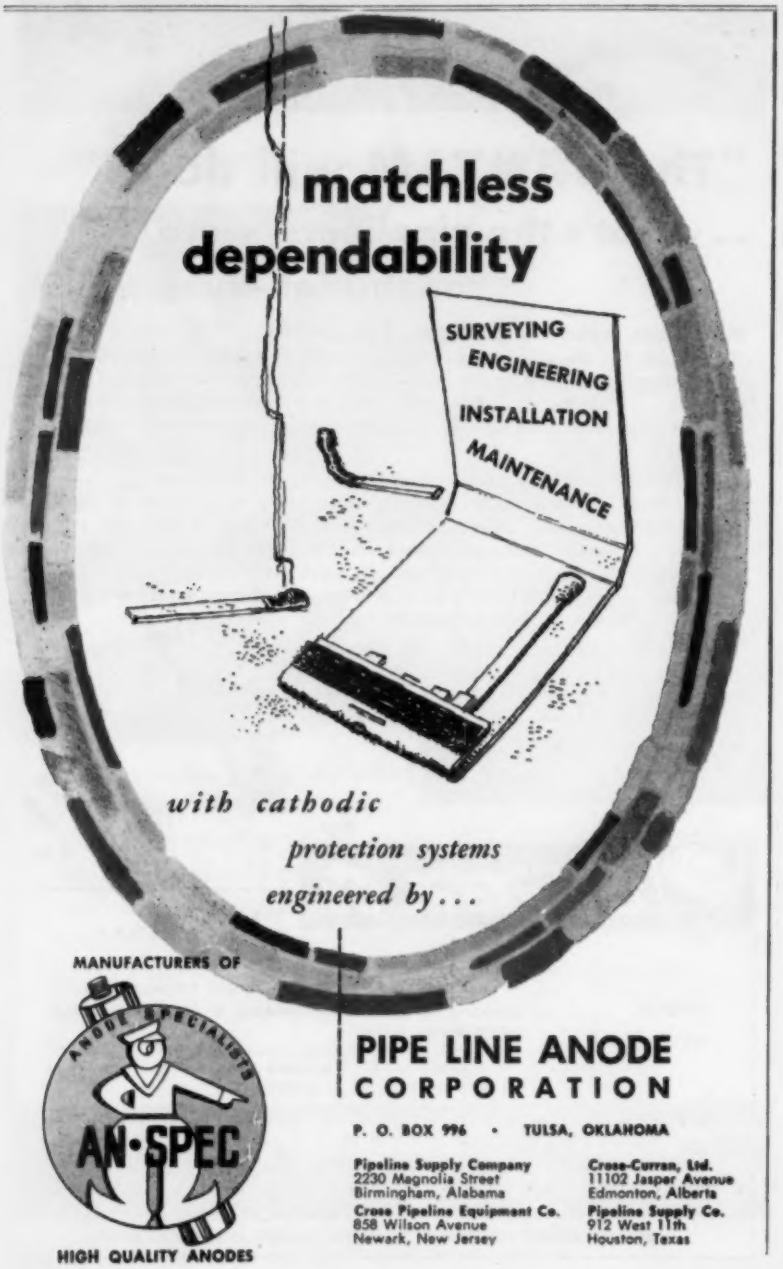
It is not the function of this paper to discuss the problem of arresting corrosion, but it has been mentioned here because corrosion and reduction of evaporation losses are the two major reasons for the application of paint to volatile-product tanks. Experiments are presently under way on painting the interior bottom ring of storage tanks in an effort to minimize corrosion.

The frequency of repainting is dependent upon a variety of factors. With careful surface preparation and application, some paints have performed satisfactorily for 10 to 15 years, according to a report made by the Humble Oil and Refining Company; whereas, in corrosive areas, the life of paint has been restricted to 3 to 6 years.

Magnolia Petroleum Company has proved that selection of the proper surface treatment is vital to success of the painting job. Magnolia treated four sections of a tank roof with various preparations. After 20 months one section still had an excellent surface coat although others had failed. This section had been pretreated with a special penetrating-oil preparation which assured the necessary bond.

Data have been obtained in a typical eastern marketing area in our own company which indicate that the average period between repainting storage tanks is three to four years for white roofs and five years for aluminum paint on the tank shells. Another area reports a somewhat longer average life of aluminum shell paint, varying from 5 to 10 years depending upon the location of the terminal; i.e., close to salt water or industrial locations on the one hand, or located inland on the other. In this former area special attention is paid to the problem of repainting. In regard to the relative life of white and aluminum, a well-formulated slow-chalking white should give four to five years life on the shell provided that the life of aluminum is known to be six years.

Cost of Materials and Labor. In analyzing painting costs it is essential to realize that labor costs constitute approximately 80 per cent of the total costs. Accordingly, it is good policy to use the most suitable paint, even if the paint cost is somewhat higher.



On methods of paint application to storage tanks, the oil industry generally has used three methods, viz., brush, spray, and roller. A brief discussion of these methods is warranted. Brush painting is the oldest and slowest method, and the application is not usually uniform from one painter to another. This method is relatively costly and old-fashioned, and is not recommended.

Spray painting, which has been used to a considerable extent in the past few years, is easy and much faster than brushing, but is no longer preferred for the following reasons:

a. Paint may be blown from tank and cause damage by splattering on parked automobiles and adjacent building.

b. Spray painting requires the painter to wear a face mask which is objectionable.

c. The application of spray paint varies with the technique used by the individual painter.

Present developments indicate that a long nap roller, the most recent equipment, is the best method of paint application and is the most economical in regard to labor costs. Further, painting by roller usually results in a more uniform application. In the case of my own company, the use of a long nap roller is the recommended method for storage tanks.

The cost of repainting tanks will vary depending upon the size of the tank and the size of the job, whether or not spot priming is included, and the number of finish coats. In Socony Mobil, available data indicate that, for spot priming and one finish coat, a cost of 5 cents per square foot, including labor and material, may be used for both roof and shell. Obviously this is an average figure and should not be used indiscriminately.

With reference to original painting of a new tank, if it is assumed that the tank is to be sandblasted, given 2 primer coats and then 2 finish coats, an approximate cost would be 15 to 18 cents per square foot, including labor and materials. It is of some interest to note that the prices quoted either for repainting or for the original application are identical regardless of whether the color of the paint is white, aluminum, gray, or pastel. If the price is quoted on a contract basis, apparently it makes little difference whether a spray or roller type of application is used.

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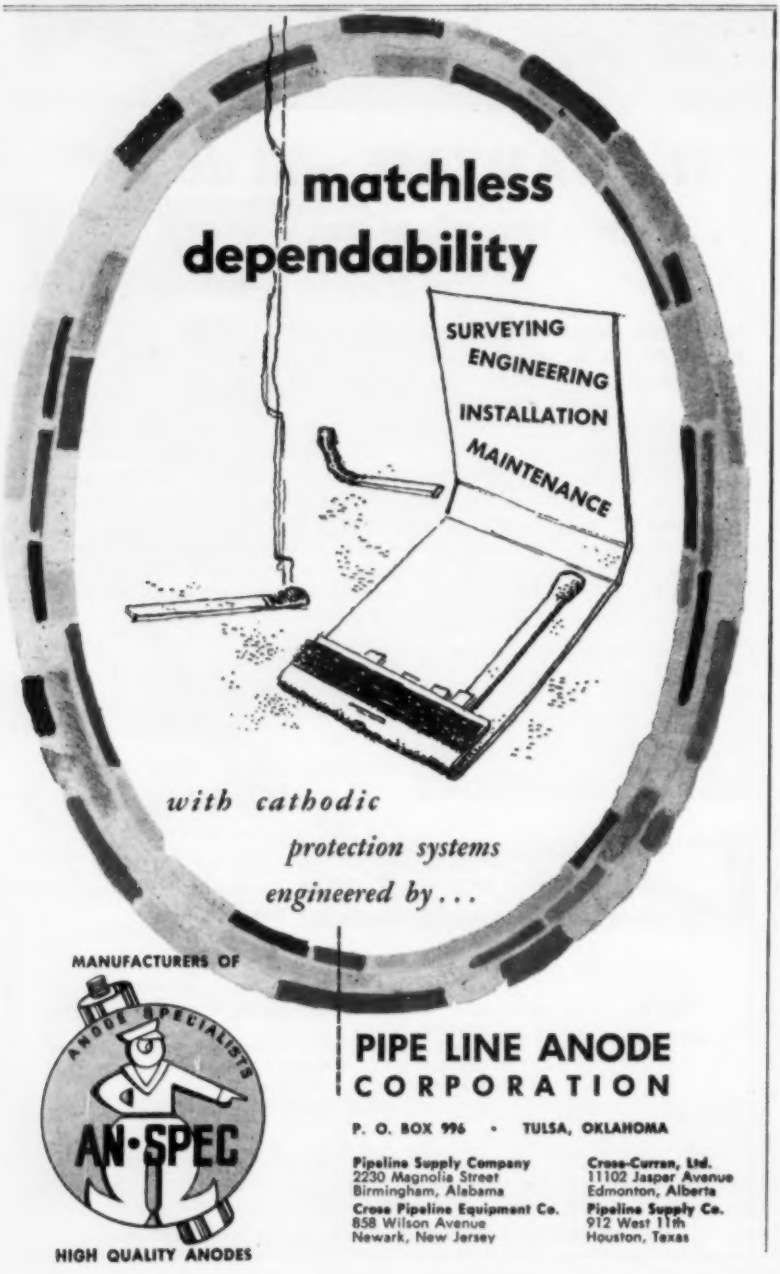

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older floating-roof tanks the shell is frequently riveted. When such tanks are used to store gasoline, savings in breathing loss again warrant the use of a white shell paint. Where crude oil is stored in older floating-roof tanks, each case must be considered on its own merit.

At the present time, many oil companies use white on both the roof and shell of tanks storing volatile products. In some cases this procedure was followed prior to the Smith and Harden article. These companies include Phillips Petroleum Company, Standard Oil Company (Indiana), The Standard Oil Company (Ohio), and some terminals of Shell Oil Company and Esso Standard Oil Company. Socony Mobil, which paints roofs white, is giving consideration to painting the shell white.

In regard to the newer tank colors now appearing on the market, aluminum — in its ordinary form or in any of the the tinted varieties — is not recommended for either tank shell or roof for volatile-product storage. Certain of the pastel colors, such as cream or light yellow or light blue, may be used on the shell of the tank for eye appeal, inasmuch as there is only a slight loss in reflectivity. However, tank shell paint must have self-cleansing properties to a comparable degree with the white paint which would ordinarily be specified.

High solar-heat reflectance is maintained only by controlled chalking. During early exposure white paint collects dirt and grime. However, in a short time the accumulations should disappear. This necessary and favorable action is brought about by controlled chalking. Self-cleansing, as one would expect, proceeds only at the expense of the paint film, which gradually weathers away and becomes thinner. It is thus seen that the requirements — maintaining high solar-heat reflectance and providing long life and protection — are working one against the other.

However, with modern highly durable alkyd vehicles and proper selection of the titanium-dioxide white pigment, the paint technician produces paints which either accelerate the chalking rate or delay it to practically any desired degree. We may thus produce a tank white paint which weathers very slowly, providing extremely long life and protection. Such a paint will soil objectionably and defeat the purpose for which it is used — high solar-heat reflectance. On the other hand, we may accent the chalking rate to such a high degree that reflectance is maintained at the expense of durability. However, with proper formulation chalking may be satisfactorily controlled and a balance struck between the two major requirements — whiteness and durability. From present indications the preferred method of tank paint application will involve the long nap roller. It gives the best coverage of paint and is the most economical in regard to labor costs.

Acknowledgment

The writer wishes to express his appreciation to Dr. P. L. Lotz of Socony Paint Products Company for his invaluable technical assistance in the preparation of this paper.

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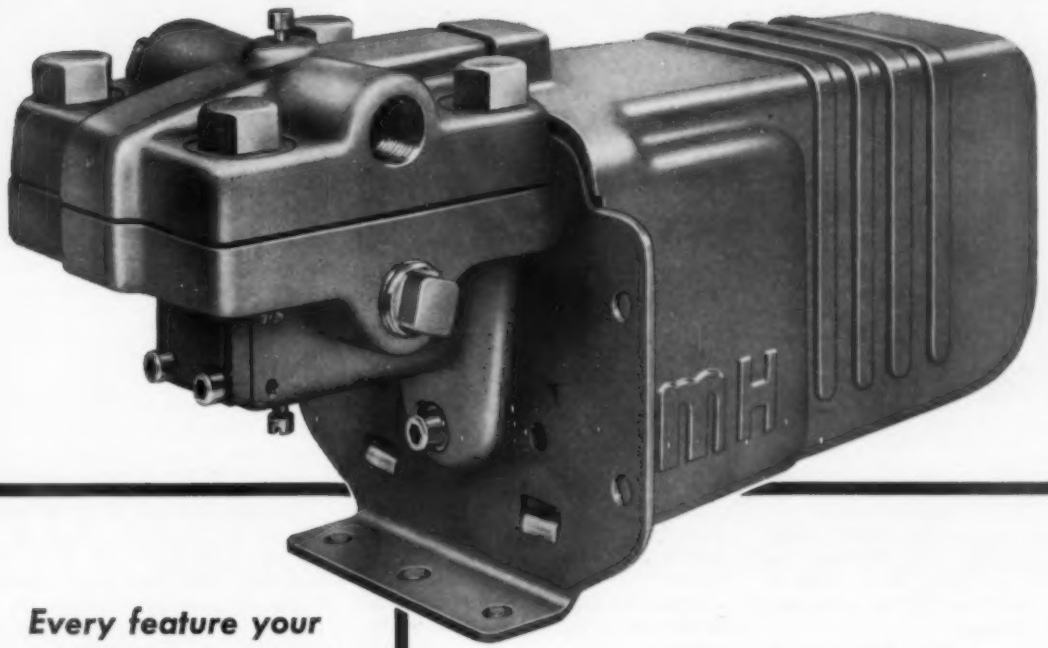

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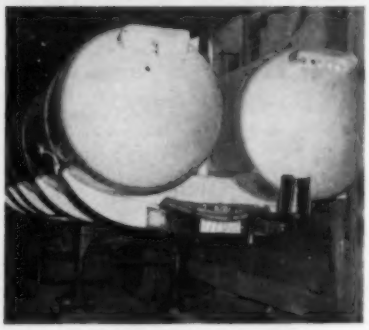

Standard butane tank car (above, left) used in transfer of natural gas from Southern California Gas Company to Portland Gas and Coke Company. (Above, right) Pressure vessel used at Portland, Oregon, to store the natural gas after tank car arrived. (At right) Trailer-mounted dual butane tanks used to deliver natural gas to Portland Gas and Coke's testing laboratory. The trailer is piped to the laboratory while gas is being used. Each tank holds approximately 860 cu ft of gas at 50 psi.

P 605

Now they've done it!

Natural Gas Shipped Via *Tank Car*

Natural gas by the carload may be a strange unit of measure and an unusual means of transportation, but that was exactly the order received by Southern California Gas Company from Portland Gas & Coke Company, Portland, Oregon.

Portland was looking forward to its changeover to natural gas and wanted a large sample to use in experiments.

The request needed careful study and preparation by both companies. Portland borrowed a propane tank car and obtained the necessary shipping permits.

Accident liability problems were discussed with SoCal's legal department, and mutual agreement was reached that the company responsibility would cease when the filled car was turned over to Southern Pacific Railroad. Safety Engineer E. E. Taylor reviewed the operation in terms of accident prevention and applicable safety codes.

Then it was necessary to find a source of natural gas that would be comparable to what Portland will later receive, at a pressure above 250 psi, and reasonably near a railroad siding.

Gas from Burrel field, in northwest corner of the California company's San Joaquin Valley division, was finally selected and the borrowed tank car was spotted on a siding paralleling the 10-in. transmission line.

In the actual filling process, it was necessary to lay several hundred feet of temporary line, and to purge thoroughly the tank car of residue propane vapor.

When the car had been pressurized to 225 psi, it was turned over to the railroad.

It is estimated the tank car contained 22,566 cu ft of California gas—about enough to supply an average residential customer for three months.

In the meanwhile, at the production plant of Portland Gas & Coke Company, a steam accumulator had been painted and made ready to serve as a pressure vessel to receive the gas. This pressure vessel, 8 feet in diameter and 38 feet long, has sufficient capacity for one tank car of gas at approximately 300 psi.

When the car of gas arrived in Portland, 80 feet of 2-in. pipe were laid temporarily to move gas from car to pressure vessel, which was filled with water. The initial transfer of gas was made by equalizing the pressures between the tank car and the receiver.

When the pressures were equalized and there was no further transfer of gas, a hose was connected to the liquid leg of the tank car and water was pumped into it at 150 psi to force the gas into the receiving vessel. The water pressure had to be increased to 180 psi to complete the transfer.

To make sure that all gas was out of the tank car, a test riser was opened on the pipe carrying the gas to the pressure vessel and, when water appeared, it was assumed that the tank car was free of gas and, of course, filled with water. It was then turned over to a tank car cleaning service, which took out the dome structure, dried it, made a complete inspection of it and declared it in A-1 condition for transporting LP gas again.

In order to make the gas available at Portland Gas & Coke's testing laboratory, a portion of it was transferred to a trailer-mounted butane tank which was then connected to the laboratory piping, where it will remain in place while the gas is being used.

Portland is using the natural gas to determine the conversion procedures necessary to convert appliances to natural gas. By doing extensive pretesting, it is hoped that many conversion "headaches" can be avoided in advance of actual conversion. The testing program will require approximately one tank car of natural gas every 2 months.

Total cost of shipment and handling will approximate $1500 per tank car, Portland Gas executives say, although the cost of the gas itself is only $6.50 at the point of loading. ★ ★ ★

31.5-MILE SECTION COMPLETES

California Gas Line Looping

J. B. Stumm
West Coast Editor

WITH completion of a final loop line well ahead of schedule, the California section of the big-inch Texas-to-California gas pipe line owned jointly by Southern California Gas Company and Southern Counties Gas Company is now a double-barrelled 30-in. artery bringing natural gas from Mid-Continent sources to Southern California markets.

Work on the final 31.5-mile loop section was completed, tested, and tied in at a cost of approximately $2,500,000.

The new loop covers the rugged terrain between Cactus City and Desert Center in the Mojave Desert north of the Salton Sea, and finishes the looping of the 210-mile California portion of the original Texas-California line.

The loop lines constitute a completely new 30-in. line parallel to the original line, and enables the companies to increase capacity, and at the same time provide a substantially greater amount of "line pack" storage of gas to meet peak day requirements.

Since November, 1953, when a 73-mile loop was added to the pipe line, this 31.5-mile section was the only remaining gap in the looping operation. Work on this final phase of the project began in early September. The 62-ft joints of 30-in. pipe was asphalt enamel coated and single wrapped with 15-lb asbestos felt in Los Angeles, and shipped by truck to the desolate Mojave Desert location. Deliveries were made in a volume sufficient to construct about 7.5 miles per week.

A considerable amount of field bending was required to conform to the irregular contours of the desert terrain.

The original Texas-California pipe line was begun shortly after World War II as a joint venture of Southern California and Southern Counties Gas Companies, and was placed in operation in 1947. Since that time, facilities have been expanded continuously in a program that has seen the initial investment of nearly $100,000,000 grow to more than $500,000,000.

Deliveries of gas through the line are now more than five times those of the original line, providing about 65 per cent of the primary gas supply for the two companies. ★ ★ ★

DRY GULCH SPAN is lowered into place during construction of the 31.5 mile, 30-in. loop line. Note existing line about 40 ft to the rear.

KING-SIZED WELDING FITTINGS are fitted together during fabrication of a pipe section that will span a wash in the desert area.

OIL PIPE LINE REVENUE AND TRAFFIC SHOW INCREASE

(Third quarter report of Interstate Commerce Commission)

Name of company	Transportation revenues (Accounts 501 and 551) 1955	1954	Per cent increase	Number of barrels of oil originated on line and received from connections 1955	1954
American Oil Pipe Line Co.[1] [2]	$ 2,102,407	$ 1,997,949	5.2	14,157,793	13,719,123
Arapahoe Pipe Line Co.	1,103,381	—	—	7,959,648	—
Arkansas Pipe Line Corporation	526,862	540,721	d 2.6	3,196,033	3,074,249
Atlantic Pipe Line Company	2,212,991	2,020,960	9.5	15,843,229	16,838,265
Badger Pipe Line Company[3]	377,865	—	—	2,710,342	—
Bradford Transit Company	142,769	154,755	d 7.7	956,863	1,344,581
Buckeye Pipe Line Company	4,081,620	3,658,307	11.6	51,808,487	46,040,703
Buffalo Pipe Line Corporation*	244,125	200,048	22.0	3,259,297	2,783,599
Cherokee Pipe Line Company	1,288,382	271,572	—	8,692,745	3,023,089
Cities Service Pipe Line Company	1,773,405	1,681,674	5.5	20,975,558	20,248,311
Continental Pipe Line Company[1]	1,787,756	1,232,411	45.1	19,582,670	15,350,915
Cooperative Refinery Association	288,627	266,629	8.3	2,563,844	2,444,918
Crown—Rancho Pipe Line Corporation	202,575	197,670	2.5	1,227,381	1,107,795
Eureka Pipe Line Company	266,875	308,545	d 13.5	614,835	809,950
Freedom-Valvoline Oil Company	120,277	66,913	79.8	1,753,802	896,319
General American Pipe Line Company[3]	86,629	83,586	3.6	1,510,984	1,416,921
Great Lakes Pipe Line Company*	8,533,387	8,949,496	d 4.7	19,955,474	19,468,518
Gulf Refining Company	8,984,293	8,039,564	11.8	74,572,946	70,227,446
Humble Pipe Line Company	9,106,680	8,268,414	10.1	62,362,092	58,403,397
Illinois Pipe Line Co., of Texas	185,444	198,512	d 6.6	2,382,691	2,545,358
Interstate Oil Pipe Line Company	5,046,898	4,726,277	6.8	39,722,119	37,846,206
Kaneb Pipe Line Co.*	298,075	130,589	128.3	2,396,924	1,250,166
Kaw Pipe Line Company	719,829	718,565	.2	11,130,738	10,793,545
Keystone Pipe Line Company*	1,321,362	1,159,204	14.0	10,243,238	8,992,578
Lakehead Pipe Line Company, Inc.	3,548,680	2,802,504	26.6	12,215,621	10,167,620
Magnolia Pipe Line Company	9,253,395	8,452,391	9.5	42,609,063	42,283,946
Michigan-Ohio Pipeline Corporation[1]	262,204	228,559	14.7	3,744,391	3,140,673
Mid-Valley Pipe Line Company	3,364,955	3,599,207	d 6.5	15,143,196	14,887,191
Nantucket Pipe Line Company	135,223	141,655	d 4.5	781,144	1,092,787
National Transit Company	424,664	451,990	d 6.0	3,442,732	3,756,580
New York Transit Co., Inc.[3]	183,196	158,460	15.6	4,949,340	4,391,918
Northern Pipe Line Company	192,530	165,487	16.3	5,326,848	4,493,402
Ohio Oil Company, Pipe Line Dept.	3,979,164	3,286,024	21.1	46,127,167	40,804,028
Oklahoma, Mississippi River Products Line Inc.	782,728	245,125	219.3	3,502,381	2,409,966
Phillips Petroleum Company*	441,493	410,496	7.6	792,354	729,749
Phillips Pipe Line Company	6,770,040	6,107,996	10.8	31,259,583	27,174,672
Pioneer Pipe Line Company	348,206	396,103	d 5.7	844,468	920,270
Plains Pipe Line Company	105,334	355,183	d 70.3	1,206,463	3,124,441
Plantation Pipe Line Company*[4]	6,617,656	5,877,252	12.6	21,955,836	18,786,290
Platte Pipe Line Company	2,873,340	3,771,606	d 23.8	13,154,305	15,308,370
Portland Pipe Line Corporation	1,388,613	915,759	51.6	17,044,910	11,854,606
Project Five Pipe Line Corporation*	255,385	269,943	d 5.4	3,461,430	3,486,807
Pure Transportation Company	1,299,652	1,286,318	1.0	18,418,764	15,233,032
Salt Lake Pipe Line Company	2,601,856	2,302,871	13.0	8,545,352	7,391,393
Service Pipe Line Company	12,940,783	13,277,592	d 2.5	40,322,939	41,296,153
Shamrock Oil and Gas Corp.*[3]	190,353	151,266	25.8	399,725	318,576
Shell Pipe Line Corporation	7,937,712	7,075,123	12.6	36,184,736	35,181,108
Sinclair Pipe Line Company	11,590,244	10,092,131	14.8	60,063,208	49,353,173
Socony-Mobile Oil Company, Inc.[1]	166,260	176,041	d 5.6	3,473,655	3,546,562
Sohio Pipe Line Company*	1,562,022	1,465,997	6.6	15,474,081	13,750,162
Southeastern Pipe Line Company	700,253	693,165	1.0	3,192,890	3,166,939
Sun Pipe Line Company	3,403,183	3,325,953	2.3	24,590,993	25,066,201
Texaco-Cities Service Pipe Line Co.[5]	2,466,325	2,114,984	16.6	21,607,980	17,859,659
Texas-New Mexico Pipe Line Company[1]	2,357,864	2,041,555	15.5	26,038,590	23,497,587
Texas Pipe Line Company[1]	9,044,309	7,604,101	18.9	61,583,509	52,689,240
Tidal Pipe Line Company	154,901	220,287	d 29.7	2,710,618	3,501,588
Tide-Water Pipe Company, Limited[6]	49,509	32,746	51.2	—	173,609
Toronto Pipe Line Company	513,277	491,057	4.5	6,724,096	6,998,857
Triangle Pipeline Company*	665,278	753,772	d 11.7	4,944,523	5,323,184
Tuscarora Pipe Line Company Limited*	471,274	434,217	8.5	2,365,871	2,339,140
Utah Oil Refining Company	767,454	761,150	.8	5,124,894	4,939,490
West Texas Gulf Pipe Line Company	1,701,844	1,630,368	4.4	28,189,015	27,971,826
Wolverine Pipe Line Company*	665,029	504,986	31.7	3,411,706	2,420,960
Wyco Pipe Line Company*	587,719	552,978	6.3	1,805,306	1,684,907
Wyoming-Nebraska Pipe Line Company	152,918	—	—	557,438	—
Yellowstone Pipe Line Company	516,198	183,429	181.4	1,273,443	614,844
Total	154,235,537	139,653,188	10.4	984,144,297	891,757,458

*Company engaged primarily in handling refined petroleum.
[1] Number of barrels of oil is total delivered out of system.
[2] Formerly Pan American Pipe Line Co.
[3] Commenced filing as of First Quarter, 1955.
[4] Formerly Socony-Vacuum Oil Company, Inc.
[5] Formerly Texas-Empire Pipe Line Co.
[6] Transportation revenue for 1955 represents pipeage on oil previously received into their system, the barrels of which were included in previous reports at time of receipt from connections.

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JOHNS-MANVILLE JM PRODUCTS **Johns-Manville** PRODUCTS FOR PIPE LINE PROTECTION

Pipe Line Projects

Phillips Builds New Products Terminal

Phillips Petroleum Company has acquired a 66-acre site at Arlington, Texas, mid-way between Dallas and Fort Worth, and construction begun on a new petroleum products terminal to serve this area, according to K. S. Adams, chairman, and Paul Endacott, president of Phillips.

The terminal will be supplied with products from the company's Sweeny refinery, south of Houston. Phillips is building a 12-in. pipe line from Sweeny to Houston, from which point another pipe line will deliver the products to the Arlington terminal. Operation of the terminal is expected to begin by May 1956.

Texas Eastern Applies For $150,000,000 Project

Texas Eastern Transmission Corporation has applied for a new $150,000,000 construction and expansion project. Application, filed with FPC, includes request for construction of a new 30-in. pipe line from Beaumont, Texas to McAllen, Texas on the Mexican border, and for expansion of the existing 30-in. system from Beaumont to New Jersey by addition of compressor station horsepower and loop lines as necessary.

The new line would provide Texas Eastern with additional supply facilities and increased system capacity for the sale, principally to existing customers, of about 250,000,000 cu ft of gas per day extra, George T. Naff, company president reported. The additional 22,000,000 cu ft proposed — Texas Eastern has at present firm requirements for additional gas service totaling 228,000,000 cu ft per day — will supply anticipated future demands, Naff added.

A contract recently agreed on by Texas Eastern and Petroleos Mexicanos allows the former to purchase and receive at the international border between Mexico and United States up to 200,000,000 cu ft of gas per day.

Proposed facilities include:

The proposed facilities include (a) about 422 miles of 30-in. pipe line from the Rio Grande River near McAllen, to Texas Eastern's Vidor, Texas, compressor station; (b) about 530 miles of 30-in. loop lines along the company's existing pipe line between Kosciusko, Mississippi, and Uniontown, Pennsylvania; (c) approximately 45 miles of 24-in. pipe line from a point of connection with the company's facilities near Provident City to a connection with the proposed 30-in. line described under (a) above in Matagorda County; (d) approximately 135 miles of supply and sales laterals; (e) five new compressor stations totaling 50,000 hp; (f) additions to existing compressor stations on Texas Eastern's present 30-in. line amounting to 20,780 hp; and (g) such metering and regulating stations as are required. The expansion of facilities in Pennsylvania will be accomplished in part through the company's wholly-owned subsidiary Texas Eastern-Penn Jersey Transmission Corp.

PG&E Asks State to OK $20,686,000 Gas Line Project

Because "the consumption of natural gas in California is growing even more rapidly than the population," Pacific Gas and Electric Company went before the California Public Utilities Commission and sought approval of a $20,686,000 project to increase by 25 per cent the daily volume of gas it imports from out-of-state fields.

In order to carry the increased deliveries the company would invest the $20 million in building 149.6 miles of 34-in. steel pipe in parallel sections to its Super Inch transmission line from Topock, Arizona, north to Milpitas. With other "loopings" having been made in 1953 and 1954, this would result in all but 70 miles of the 502-mile line having parallel sections. Additional compressor capacity totaling 9,260 brake horsepower would be added to the three PG&E stations at Topock, Hinkley and Kettleman, increasing their total to 76,120 bhp.

Magnolia Begins Work On West Texas Line

Magnolia Pipe Line Company has begun preliminary work on a new pipe line in Andrews County, Texas, according to an announcement made by L. H. True, company president.

The line will extend from Magnolia's Andrews Station, located in the SE ¼ of Section 8, Block A-44, Public School Lands survey, to the McFarland-Queen sand and the Nolley-Queen sand fields in north central Andrews County. Approximately 14 miles of 8-in. line will be laid with necessary 4-in., 6-in., and 8-in. feeder lines to serve leases in the area now producing sour crude.

Gas Industry Revenues Pass $5-Billion Mark

Operating revenues of the gas pipe line and utility industry passed $5 billion for the first time in any 12-month period. For the year ended September 30, 1955, the AGA reports, total operating revenues showed an increase of $656,000,000, or 14.7 per cent above the comparable period last year. Net operating revenues increased from $575,000,000 to $665,000,000 in the same period, a gain of 15.7 per cent. Net income of $487,000,000 for the 12-month period was 10.7 per cent greater than the $440,000,000 for the similar period one year earlier.

Total taxes for the 12-month period were $646,000,000 or 12.6 per cent of total operating revenues received by the gas utility industry. This figure is 19 per cent greater than the amount paid last year. Total taxes paid by the industry were 32.6 per cent greater than the net income available to stockholders.

Iraq Petroleum, Syria Sign New Contract

Iraq Petroleum Company Ltd. has reached agreement with the Syrian government on the revision of payments under its 1931 Convention in respect to the company's pipe line and terminal operations in Syria.

Agreement reached in Damascus on November 26 will give the Syria Government a revenue of some $18,200,000 on the expected rate of throughput of approximately 26,000,000 tons during 1956.

The sum of $18,200,000 is made up of payments on a hundred-ton-mile basis for the distance traversed through Syrian territory, amounting to $16,800,000, equivalent to 50 per cent of the calculated profit on the pipe line and terminal operations in Syria. In addition, there are port dues and security payments amounting to $1,400,000 yearly.

Texas Gas Meets Public With Pipe Line Display

Texas Gas Transmission Corporation is using an eight-foot high pipe line display board to acquaint the public with how the company transports natural gas from south Louisiana and East Texas fields to industrial and utility customers along its 3000-mile pipe line.

Bubbling blue water, running through plastic tubing pipe lines, simulates the actual flow of natural gas. A narration, synchronized with flashing lights that denote locations of various pipeline facilities, explains operations through which the fuel passes from the

gas well to the housewife's kitchen range.

Plans are underway for an especially designed trailer to transport the exhibit to showrooms of distribution system customers where it will be on display to the public.

Back to Products in June For "Little Big Inch" Line

Texas Eastern Transmission Corporation has announced that construction will get underway early in May to convert the "Little Big Inch" of World War II fame from gas service back to its original role as a products carrier to the Eastern seaboard. The work is scheduled for completion early in June.

The reconverted system will be more efficient that it was when it first went into operation in February 1944, at the height of the war effort, say Texas Eastern engineers. The capacity will be about the same — 235,000 bbl of gasoline per day — but improved pumps, operating and maintenance practices will make it more economical than before.

To make the conversion from gas service, which dates back to 1947, Texas Eastern has spent $71,000,000 on new facilities to increase the capacity of its Eastern leg by an amount equal to that being carried by the 20-in. diam "Little Big Inch". Aside from this, the company will effect the reconversion at little cost, because prime movers and switchgear at the original stations are still intact.

Engineers are planning to utilize the best advances in automation and one innovation already announced is that controls will be effected over AT&T's new SC-1 circuit.

Southern Cal Applies For Pipe Line Right

The Southern California Gas Company and the Southern Counties Gas Company recently filed an amended application with the California Public Utilities Commission calling for the construction of a 236-mile pipe line from Topock on the Colorado River to Newhall.

The new line will bring an additional 177,000,000 cu ft of gas daily from out-of-state to supply the two companies' two million customers in Southern California. The Federal Power Commission has authorized the El Paso Natural Gas Company to increase its deliveries to the Southern California companies by that amount.

The present pipe line system bringing gas into Southern California from out of state runs from Blythe to Santa Fe Springs. The new system will take the gas at Topock on the state line near Needles and will terminate at Newhall.

Pipe Line News

Shell Buys Pipe Line In New Mexico

Shell Pipe Line has purchased 85 miles of 2 to 8-in. gathering lines and 49 miles of 8-in. trunk line in Lea County, New Mexico from Humble Pipe Line Company.

Shell's gatherings will be increased by about 6500 bbl per day and millions of barrels of connected reserves will be added to the system. Fields served by the gathering system include: Bowers, Brunson, Cooper-Jal, Drinkard, Eunice-Monument, Eunice-South, Hobbs, Jalmet gas pool, Langlie-Mattix, Paddock, and Penrose-Skelly.

The 8-in. trunk line runs from Hobbs south to the Texas-New Mexico border and includes two main line pump stations at Hobbs and Dublin.

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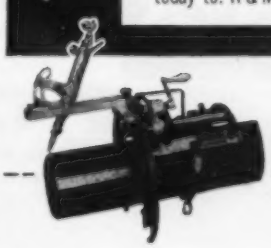

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AGA General Management Conference Set For April

A wide selection of subjects, ranging from "Economic Analysis and Forecast" to "Canadian Gas Resources," will be included in the Second Annual General Management Conference program of the American Gas Association at Conrad Hilton Hotel, Chicago, April 4, 5 and 6.

Topics have been selected by the Arrangements Committee acting for the eight standing committees that make up the General Management Section. A competent speaker will discuss cost problems in business; an address will be given by Dean H. Mitchell, president of AGA; organization planning and labor-management relations will be brought under discussion. Top executives in each of these fields have been contacted to present the subjects.

A combined Insurance-Personnel session will include a presentation by a General Electric representative on his company's recently negotiated Comprehensive Health Plan.

The combined Corporate Secretaries-Comparison of Competitive Services — Economics — Rate session will feature a speaker on a subject of general interest to the four committees represented. Open business meetings, at which top management and others who may be interested can see active committees at work, will be sponsored by the Accident Prevention Committee, as well as the four committees above.

The Purchasing and Stores Committee, in addition to presenting reports of four subcommittees, will present formal papers on: "Inventory Yardsticks," a slide picture film on warehouse designs, a paper on the value of salvage and one on continuing requisitions.

Pipe Line Tariff Filed By Railroad Company

The first tariff rate schedule ever filed by a pipe line owned by a railroad has been filed with ICC by Southern Pacific Pipe Lines Inc., a subsidiary of Southern Pacific Railroad. Tariff covers shipping of fuel oil, distillates, gasoline and jet fuels, through the line, built along the Southern Pacific right of way.

Movements covered in the tariff include those eastbound from Watson (Los Angeles), California to Colton and Niland, and Pheonix, Arizona, and westward from El Paso, Texas to Phoenix and Tuscon. Westbound rates are: 8½ cents per barrel to Colton and 28 cents to Niland. East bound rates from El Paso to Tuscon is 49 cents per barrel, and east and west bound rates to Phoenix are the same — 60 cents per barrel.

Triangle Pipeline Merges With Texas Eastern

Triangle Pipeline Company, wholly-owned subsidiary, has been merged with and into Texas Eastern Production Corporation. In turn Texas Eastern Production Corporation was merged with and into Texas Eastern Transmission Corporation, according to announcement by George T. Naff, president.

The merger of the Production Corporation with the Transmission Corporation had been overwhelmingly approved by the stockholders of each company at meetings held on November 8, 1955.

NACE South Central Region 1956 Meeting in San Antonio

San Antonio was chosen as the site for the 1956 South Central regional meeting, National Association of Corrosion Engineers. Transfer of the meeting to San Antonio was approved on application of representatives of the San Antonio Section when previous arrangements to hold the meeting at Beaumont, Texas had been cancelled.

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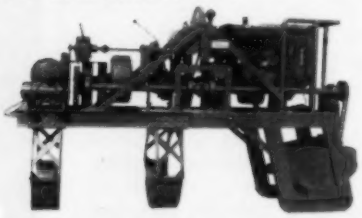

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FPC Grants Transcontinental New Pipe Line Facilities

The Federal Power Commission has issued an opinion and order authorizing Transcontinental Gas Pipe Line Corporation, of Houston, Texas, to construct pipe line facilities to enable it to receive and transport through its system an additional 29,000,000 cu ft of natural gas per day, to be purchased from several independent producers.

Under the authorization, Transcontinental will build a total of about 24 miles of pipe lines estimated to cost $754,000. The gas will come from the South Bayou Mallet, Maxie, and Happytown fields, all in Louisiana.

Gas Measurement Course To Be Held at Oklahoma

The General Committee of the Southwestern Gas Measurement Short Course has announced that the thirty-first annual short course will be held at the College of Engineering, University of Oklahoma, Norman Oklahoma, on April 17, 18 and 19, 1956.

According to Roland O. Cox, Lone Star Gas Company, chairman of the General Committee, the Executive Committee of the course has appointed the following to serve as chairman of the subcommittees indicated: Roy S. Peace, Jr., Southern Natural Gas, Program Subcommittee; R. R. McCafferty, Pioneer Natural Gas, Publications Subcommittee; D. H. Lindsey, Northern Natural Gas, Practical Methods and Registration Subcommittee; Vars W. Bates, Southern Union Gas, Exhibits Subcommittee; Miss Kate A. Niblack, Oklahoma Utilities Association, Publicity Subcommittee; Dean W. H. Carson, College of Engineering, University of Oklahoma, Local Arrangements Subcommittee; E. L. Stark, The Foxboro Company, Exhibitors Subcommittee. Other members of the General Committee serve in one capacity or another on these working subcommittees.

The General Chairman of the 1955 Short Course, K. R. Tibbets, Warren Petroleum, has served through all of the chairs of the General Committee, therefore; in accordance with established policy, he was promoted to the Executive Committee of the course. Charles R. Stephenson, superintendent of measurement, Michigan-Wisconsin Pipe Line Company, Detroit Michigan was elected to fill the vacancy on the General Committee created through the promotion of Tibbets.

N. D. Gilbert completed his tenure on the General Committee by serving as chairman of the Exhibitors Subcommittee during 1955. K. R. D. Wolfe, vice president, Fisher Governor Company, Marshalltown, Iowa, was elected to a five year term.

Natural Gas Stocks Hold High Levels

Natural gas common stocks, aided by continued strength in the general market, advanced to within a few cents of the all time high recorded two months earlier. For the period ending November 25, the index closed 14.1 per cent above the comparable period last year and only 0.24 per cent below the September high.

As the stock market advanced, transmission company stocks reacted favorably to current earnings reports and pushed strongly ahead into new high ground. At the close on November 25, this index showed a gain of 24.6 per cent over the comparable period one year earlier.

Dividend payments, unchanged during the month, caused the resultant yield to fall to 4.10 per cent. Stocks of distribution companies, advancing more slowly, ended the month 14.0 per cent above last year, and only 3.3 per cent below their all-time high.

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Pipe Line News

NPC Names Committee On Underground Storage

Walter S. Hallanan, Chairman of the National Petroleum Council, has announced appointment of a Committee on Underground Storage for Petroleum. The Committee, which was appointed in response to a request from Hugh A. Stewart, Director of the Office of Oil and Gas, Department of the Interior, is to review the industry's experience with underground storage for petroleum products and submit such report and comments as the Council deems appropriate, and include in the report information on the overall capacity of such storage now in use, by types, sizes, regional location and type of product stored.

H. S. M. Burns, president of Shell Oil Company, New York City, is chairman of the committee. Members of the committee are as follows: Hines H. Baker, president, Humble Oil and Refining, Houston; Paul Endacott, president, Phillips Petroleum, Bartlesville; R. G. Follis, chairman of the board, Standard Oil of California, San Francisco; Jake L. Hamon, Dallas, Texas; W. Alton Jones, chairman of the board, Cities Service, New York City; J. Sayles Leach, chairman of the board, The Texas Company, New York City; R. L. Milligan, president, The Pure Oil Company, Chicago; Sid W. Richardson, president, Sid W. Richardson, Inc., Fort Worth; Sidney A. Swensrud, chairman of the board, Gulf Oil, Pittsburgh; Reese H. Taylor, president, Union Oil of California, Los Angeles; and William K. Warren, chairman of the board, Warren Petroleum, Tulsa.

Sinclair Pipe Reports Previous Records Broken

All former volume records for the transportation of refined products through the products pipe lines of Sinclair Pipe Line Company were broken in November, according to L. B. Moon, vice president in charge of products lines.

Moon said deliveries during November were in excess of 5,000,000 bbl, which exceeds by 125,000 bbl any previous month's deliveries since the establishment of the company's products pipe lines system in 1942. He further stated that products deliveries during 1955 will exceed all previous 12 months totals.

Continental Line Due To Be Completed

Expansion of Continental Pipe Line Company's crude line from Guernsey, Wyoming, to Denver, Colorado, is being completed. The expansion project increases capacity of the line to 50,000 bbl daily into Cheyenne, Wyoming, and to 32,000 bbl daily into Denver. Continental Pipe Line Company is a subsidiary of Continental Oil Company.

The expansion program included addition of a 24-mile loop of 8-in. pipe betwene Guernsey in Wyoming's Platte County and Horse Creek, 30 miles northwest of Cheyenne; construction of 35,000-bbl and 55,000-bbl tanks at Guernsey and an electric booster station near Ault, Colorado, 11 miles north of Greeley; and installation of pumping units at Chugwater, Wyoming, and Horse Creek.

Plans call for operating Continental Pipe Line Company's Ault booster station remotely from Horse Creek. Station discharge, pump case and station suction pressures will be telemetered to Horse Creek and recorded.

World Gas Conference

U. S. gas companies will be hosts to nearly 200 foreign visitors attending the sixth annual conference of the International Gas Union. The sessions, slated September 25-30, at the Hotel New Yorker in New York City, will bring representatives from 17 foreign countries. This is the first time the conference has met in the United States.

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PIPE LINE PERSONALS

J. J. Schmidt

N. R. Wyckoff

Jacob J. Schmidt, general production superintendent and assistant to the president of the East Ohio Gas Company, has been appointed manager, system gas supply, for the Consolidated Natural Gas System, effective January 1st. His headquarters will be at Gateway Center in Pittsburgh, Pennsylvania. Schmidt will coordinate the production, transmission and storage of the gas supply for the entire Consolidated System, of which East Ohio is the greatest distributor. A recognized authority on gas geology, he is also well known for his work on the problems of underground storage of gas and methods of standardizing equipment used by the various companies in the gas industry.

Appointment of **Norman R. Wyckoff** as superintendent of Southern Counties Gas Company's Texas pipeline division has been announced. He succeeds **E. A. Wallace,** who has resigned from the company. Wyckoff, most recently construction and maintenance supervisor in the utility's San Gabriel Valley division, has had extensive background in pipeline construction and maintenance.

In his new post he will have charge over Southern Counties' entire Texas pipeline system extending from the Colorado River near Blythe to the Los Angeles metropolitan area.

M. V. Cousins and **C. C. Barnett** have been elected vice presidents of United Gas Pipe Line Company, a subsidiary of United Gas Corporation, at a meeting of its board of directors recently. Cousins has been a member of the board since March of this year, and Barnett was elected to the board in November. **D. D. Dillingham** was appointed assistant to **Ed Parkes,** recently elected vice president and general manager of United Gas Corporation and its wholly owned subsidiaries, and **V. S. Brennan** was named personnel director of the companies.

Standard Oil Company (Indiana) has made a number of products pipeline appointments in its supply and transportation department. **S. A. Hallberg,** Twin Cities division superintendent at Minneapolis and St. Paul, Minnesota, was named Chicago division superintendent pro-tem, relieving **R. T. Scott,** who is convalescing. **N. F. Tietze,** district superintendent at Spring Valley, Minnesota, succeeds Hallberg. **C. G. Weibel,** Twin Cities division engineer, replaces Tietze as district superintendent at Spring Valley. **C. W. Bergstrom** of the products pipeline engineering division at the company's general office at Chicago succeeds Weibel.

E. M. Kelley, El Paso district manager of Southern Union Gas Company, has been promoted to southern division manager of the gas company's western properties. Kelley's promotion was effective December 1. Kelley, whose headquarters will remain in El Paso, will supervise and assist in the operations of the company's Southeastern New Mexico and West Texas districts in addition to his present supervision of the El Paso and Alamogordo districts. The new position has been created due to the rapid growth and expansion of all western area properties of Southern Union. The four districts have been redesignated as the southern division.

Homer R. Swift, superintendent, right of way, Service Pipe Line Company, was elected president of Heart of America Chapter No. 5, American Right of Way Association, at the regular meeting of the chapter members in Kansas City, December 9. During the past year, Swift has served the chapter as its first vice president. His term as president is one year. He is also a director of the national association and regional chairman of the Heart of America region.

Harry E. Waldrip, Gulf Oil Corporation, Houston, has been elected director representing south central region on the board of directors of the National Association of Corrosion Engineers. His term of office will begin March 16, 1956. Waldrip, who was regional chairman in 1953, has held almost all regional offices. He succeeds **Derk Holsteyn,** Shell Oil Company, Houston.

Wilbert K. Smith, assistant superintendent of the Ohio Oil Company's Martinsville, Illinois, pipeline division, has been appointed division superintendent. He succeeds **Oscar M. Jaco,** who retired December 1 after almost 46 years with the company. He was born in Martinsville and attended school there. He started with Ohio Oil in 1910 at the Martinsville tank farm. Smith first worked with Ohio Oil in 1916 and spent 16 years in Texas. He transferred to Martinsville in 1942 where he was a fireman, station engineer, district foreman and in 1951 was appointed construction superintendent. He was named assistant division superintendent in 1954.

E. Clyde McGraw of Houston was elected executive vice president of Transcontinental Gas Pipe Line Corporation, Houston, at a November meeting in New York of the board of directors. McGraw had been Transco's vice president in charge of operations since joining the company July 1, 1950. Transco is the major supplier of natural gas to the New York-New Jersey-Philadelphia metropolitan area and serves a number of utility customers in the southern states through which the big line passes.

E. C. McGraw

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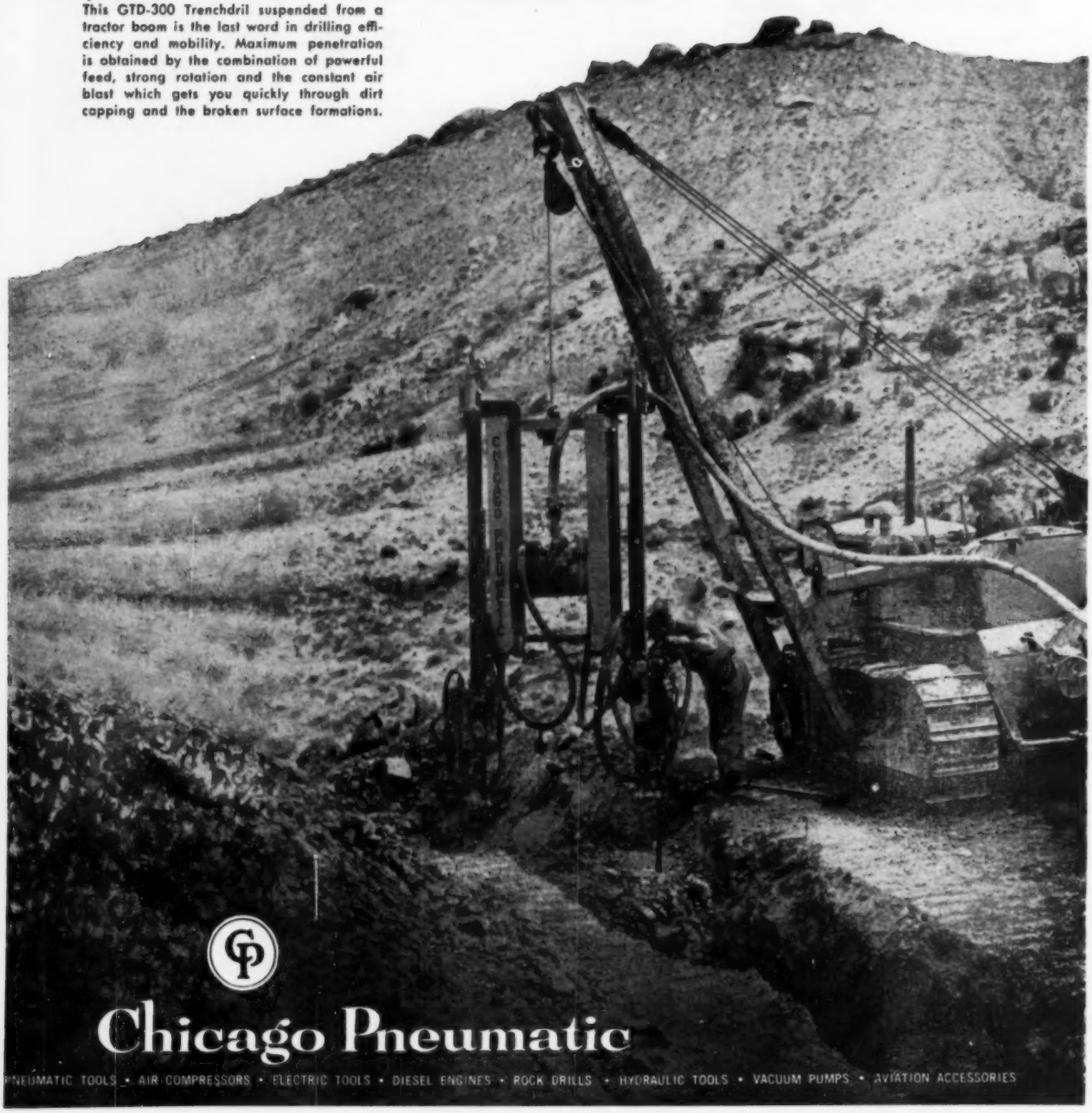
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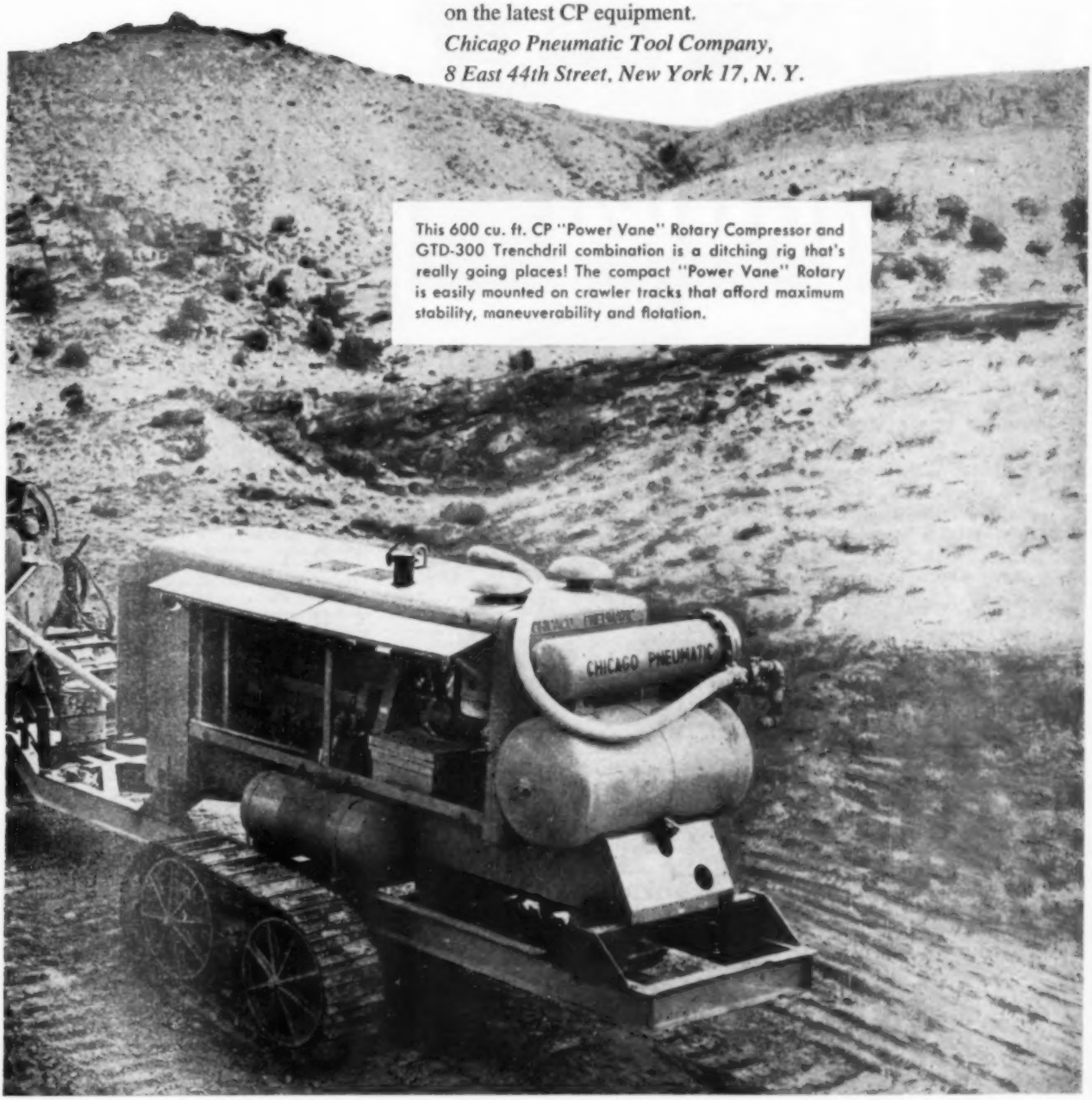

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Personals

▸ **Joseph F. Weiler** has been appointed attorney in charge of the legal department of Texas Eastern Transmission Corporation. Prior to employment with Texas Eastern, Weiler was for five years an attorney for Transcontinental Gas Pipe Line Corporation, and before that was a staff attorney for the Federal Power Commission from 1946 to 1950.

▸ **Captain George Larimer,** alumnus of Pennsylvania's school ship, the "U.S.S. Annapolis," has been made port captain at Sun Oil Company's tankship fleet headquarters in Marcus Hook, Pennsylvania. He succeeds **Captain Robert J. Ball,** retired. Captain Larimer was graduated from the Pennsylvania State Nautical School — better known as the school ship. Joining the Sun fleet as an able-bodied seaman in 1938, he came up through the ranks and won his first command in 1944.

R. D. Grimm

▸ Northern Natural Gas Company has announced the appointment of **R. Dean Grimm** of Bartlesville, Oklahoma, to the newly created position of manager of reserves and availability in Northern's gas supply department. He has been assistant manager of the gas reservoir department of Phillips Petroleum Company. Grimm was graduated from Missouri School of Mines in 1937 with a BS degree in petroleum engineering and has served in various capacities with Phillips Petroleum Company.

▸ Standard Oil Company (Indiana) is making a number of changes in the organization of its supply and transportation department. **S. L. Jackson** will be manager of transportation. He will direct product movement and the operation of products pipe lines and marine facilities. He is manager of products pipe lines. **W. A. Bennett** will become manager of distribution. He will direct distribution planning and the operation of terminals. He is assistant manager of products pipe lines. **R. B. Rodgers** will be general superintendent of distribution planning. He will supervise planning for the distribution of bulk products from river, lake, and pipe line terminals, and from refineries. **J. R. Olson** will be appointed superintendent of distribution planning. **D. V. Hartzell** will be appointed general superintendent of terminals. **F. M. Palmer** and **R. M. Shearer** will become assistant general superintendents of terminals.

▸ **Forrest W. Lewis, Jr.,** of Owensboro, Kentucky, has been appointed manager of the newly-created gas storage department of Texas Gas Transmission Corporation. In his new position, Lewis will direct the development and operation of the company's program of underground storage of natural gas. Lewis formerly was a senior engineer in the measurement and research department.

▸ **Jack Clarke,** formerly director of public relations for Texas Eastern Transmission Corporation, has been elected executive vice president of Freestate Industrial Development Company, Shreveport, Louisiana. The new firm is giving consideration to future expansion into the field of oil and gas production and represents the biggest real estate development in the history of Shreveport.

▸ **W. M. Wilson,** who has been general superintendent of gas, natural gasoline and pipe line operations stationed at the El Dorado, Arkansas, headquarters of Lion Oil Company, a division of Monsanto Chemical Company, has been named manager of the southwestern region with headquarters at Midland, Texas. He replaces **F. H. McGuigan,** who has resigned effective December 31 to devote his full time to administration of a family estate. **Robert P. Evans,** who has been northern area supervisor at Billings, Montana, is being transferred to Midland as assistant regional manager. **Quinton Drake** will replace Wilson as superintendent of gas and natural gasoline operations at the El Dorado office. He has been gas engineer under Wilson.

▸ **W. T. Stevenson,** Owensboro, Kentucky, president of Texas Gas Transmission Corporation and Western Kentucky Gas Company, has been appointed to the advisory council of the Southern Institute of Management. Stevenson will work with other prominent Southern businessmen and educators in helping to formulate the policies and programs of the non-profit foundation that is directing concerted attention to methods of judging, rating and appraising business management in 13 southern states. Howard C. Bowles, executive vice president of the institute, said Stevenson's appointment "brings to the Advisory Council broad experience in the natural gas field, general business and community development that is invaluable to the growth of the South and to excellence of management." The Southern Institute of Management is affiliated with the American Institute of Management. It also is the Southern service bureau for Who's Who in America.

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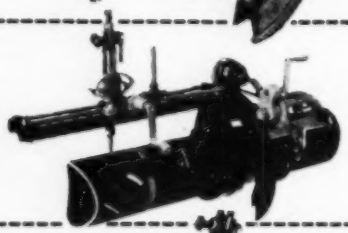

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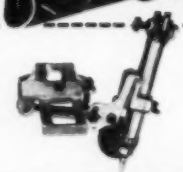

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WITH THE PIPE LINE CONTRACTORS

● **Associated Pipe Line Contractors, Inc., P. O. Box 13216, Houston 19, Texas.** Has 6 miles of underwater crossing across Lavaca Bay for *Tennessee Gas Transmission Company*. Job consists of laying 30-in. concrete coated pipe and a parallel 6-in. natural gas line. Has 36 miles of 26-in. natural gas line from Lake Arthur to North Tepetate pumping station, Louisiana, for *American-Louisiana Pipe Line Company*. Has 200 miles of 30-in. main line from lower part of Louisiana to Arkansas-Louisiana state line for same company; three major crossings on the Red, Ouachita, and Mississippi rivers are included in this project.

● **Baughman Contracting Company, Inc., R. D. 1, Box 569, Cumberland, Maryland.** Has undetermined amount of 2 to 16-in. gas main transmission and distribution lines in Maryland, Ohio, Pennsylvania, and West Virginia for *Manufacturers Light and Heat Company, Natural Gas Company of West Virginia, and the Cumberland and Allegheny Gas Company*.

● **Bechtel Corporation, 220 Bush Street, San Francisco, California.** Has joint venture with Conyes Construction Company on 400 miles of the 30-in. *Westcoast Transmission Company, Ltd.*, line from Peace River area of Alberta to Vancouver and U. S.-Canadian border.

● **Brown & Root, Inc., 4100 Clinton Drive, Houston, Texas.** Has prime contract on 200 miles of 30-in. natural gas line for *American-Louisiana Pipe Line Company* from South Louisiana to Arkansas-Louisiana state border.

● **O. R. Burden Construction Corporation, P. O. Box 5216, Tulsa, Oklahoma.** Has 13 miles of take-up on 8-in. line and 31 miles of reconditioning scattered along a 200-mile, 96-loop line for *Magnolia Petroleum Company* near Big Spring, Texas.

● **Coates Field Service, Inc., Box 1581, Oklahoma City, Oklahoma.** Has 140 miles of 24-in. from Garvin County to Tulsa, Oklahoma, and 50 miles of 12-in. from northwest Okfuskee County to Weleetka, Oklahoma, for *Transok Pipe Line Company*. Has 93 miles of 16-in. from Blackwell, Oklahoma, to Independence, Kansas. 46 miles of 16-in. from Calista to Wichita, Kansas, and 10 miles of 12-in. from South Canadian River to Moore, Oklahoma, for *Cities Service Gas Company*.

● **Collins Construction Company, Box 256, Port Lavaca, Texas.** Has 29,600 ft of 30-in. concrete-coated pipe line across Guadalupe River and a 6-in. concrete-coated natural gas line paralleling main line for *Tennessee Gas Transmission Company* near Port Lavaca, Texas.

● **Consolidated Gas and Service Company, 327 South LaSalle Street, Chicago, Illinois.** Has miscellaneous distribution mains and service lines in up-state New York for *Niagara Mohawk Power Corporation*.

● **Conyes Construction Company, San Pablo, California.** Has joint venture with Bechtel Corporation on 400 miles of 30-in. line in the middle of *Westcoast Transmission Company's* gas line from Peace River area of Alberta to Vancouver and U. S.-Canadian border.

● **Dixie Construction Company, Savannah, Georgia.** Has 125 miles of various size distribution system for City of Dalton, Georgia.

● **Dutton-Williams Brothers, Ltd., Pacific Building, Calgary, Alberta.** Has 120 miles of 30-in. gas line for *Westcoast Transmission Company, Ltd.*, between Taylor and Azouzetta Lake, British Columbia. Has 135 miles of 10-in. natural gas line between Lake Wabamum and Hinton, Alberta, for *North Canadian Oils, Ltd.*

● **Engineering Construction Company, 402 North Cheyenne, Tulsa, Oklahoma.** Has undetermined mileage of distribution lines for Leachville and Monnette, Arkansas.

● **Fulghum Contracting Corporation, P. O. Box 1181, Harrisburg, Pennsylvania.** Has 198 miles of 22-in. natural gas line for *Pacific Northwest Pipeline Corporation* between Ontario, Oregon, to Pasco, Washington, with three submerged river crossings on Snake and Columbia rivers. One Snake River crossing has been subbed to H. B. Zachry & Company.

● **R. H. Fulton & Company, P. O. Box 1526, Lubbock, Texas.** Has 60 miles of 16-in. gas line to lay and take-up on 73 miles of 16-in. line for *Kansas Gas Supply Company* between Spivey field in Kingman County to Wichita, Kansas. Has contract on three major underwater crossings of the Green River in the Utah-Wyoming area; all are dual 20-in. submerged gas lines. Has 256 miles of 22-in. gas line for *Colorado Interstate Gas Company* between Laramie and Rock Springs, Wyoming.

● **G. G. Griffis, Inc., 4450 East Admiral Place, Tulsa, Oklahoma.** Has 90 miles of *Pacific Northwest Pipeline Corporation's* 22-in. natural gas line from Sage, Wyoming, to Lava Hot Springs, Idaho.

● **Harrelson Construction & Welding Company, P. O. Box 432, Seymour, Connecticut.** Has sub-contract on 6.5 miles of 6-in. gas lines in Danielson, Connecticut. Has undetermined amount of various sizes of steam and fuel systems in Limestone, Maine.

● **Houston Contracting Company, 2707 Ferndale Place, Houston 6, Texas.** Has joint venture with H. C. Price Co. on 783 miles of 30-in. natural gas line for *American-Louisiana Pipe Line Company* from Willow Run, Michigan, to the Arkansas-Louisiana state line near Eudora, Arkansas; work will be done in two spreads.

● **Kan-Tex Construction, Inc., Wichita, Kansas.** Has take-up on more than 70 miles of loop line in Nebraska for Rogers Lundquist Company.

● **Majestic Contractors, Ltd., 408 Royal Trust Building, Edmonton, Alberta.** Has 60 miles of 4 to 16-in. crude lines in Redwater and Simmons area of Alberta for *Imperial Oil Limited*. Has 109 miles of 12-in. crude line from Cromer, Manitoba, to Midale, Saskatchewan, for *Westspur Pipe Line Company*. Has undetermined amount of line to lay and manifold fabrication at *Interprovincial Pipe Line Company's* Cromer, Manitoba, pump station. Has undetermined amount of gas distribution lines in the Toronto area for *Consumers' Gas Company of Toronto*.

● **Mannix, Ltd., 332 7th Avenue W., Calgary, Alberta.** Has 120 miles of 30-in. gas line at the south end of *Westcoast Transmission Company's* gas line from Peace River area, Alberta, to U. S.-Canadian border near Vancouver, British Columbia.

● **McKenzie Construction Company, Lock Haven, Pennsylvania.** Has an undetermined amount of take-up and relocation work for *Socony Mobil Oil Company, Inc.*, in connection with the building of the Massachusetts Turnpike.

● **Mid-States Construction Company, P. O. Box 417, Mt. Vernon, Illinois.** Has 16 miles of 12-in. line from station at Anderson to main line near Aroma, Indiana; 5.8 miles of 6-in. lateral loop near Greenfield, and 7 miles of 6-in. lateral loop at Winchester, Indiana, all for *Panhandle Eastern Pipe Line Company*.

● **Midwestern Constructors, Inc., 105 North Boulder, Tulsa 3, Oklahoma.** Has 95 miles of 22-in. natural gas line for *Pacific Northwest Pipeline Corporation* between Lava Hot Springs and Burley, Idaho.

● **Modern Welding Company, Inc., Owensboro, Kentucky.** Has transmission system for *Shenandoah Gas Company* in Winchester, Virginia. Has transmission and distributing system for the the City of Sylvania, Georgia. Has complete transmission systems for cities of Oxford and Covington, Georgia.

● **Bill Murry & Company, 2495 Gulf Street, Beaumont, Texas.** Has take-up and relay of 30 miles of 10-in. crude line for *Shell Pipe Line Company* from Deer Park refinery to Barker Dam, near Houston, Texas.

● **Napp-Greco Construction Company, 1600 McCarter Highway, Newark, New Jersey.** Has 52 miles of 12 and 16-in. loop line from Lawrenceville to Woodbury, New Jersey, for *Transcontinental Gas Pipe Line Corporation*.

● **H. C. Price Company, Box 1111, Bartlesville, Oklahoma.** Has 45 miles of 30-in. natural gas pipe line running from Brazos River to the Houston Ship Channel, near Houston, Texas, for *Tennessee Gas Transmission Company*. Has 185 miles of 30-in. natural gas line from Hancock County line, Indiana, to Slaughters, Kentucky. Has joint venture with Houston Contracting Company on 783 miles of 30-in. for *American-Louisiana Pipe Line Company* from Willow Run, Michigan, to the Arkansas state line near Eudora, Arkansas.

● **River Construction Corporation, 6100 Camp Bowie Boulevard, Fort Worth, Texas.** Has take-up of 136 miles of 8-in. crude line between El Paso and Wink, Texas, for *Pasotex Pipe Line Company* in conjunction with laying of a 42 mile two-loop line just completed.

● **Somerville Construction Company, 6448 Fulton Road, Ada, Michigan.** Has complete distribution system in Harrison, Ohio, for *Cincinnati Gas and Electric Company*.

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Contractors

● **Sheehan Pipe Line Construction Company, 514 National Bank of Tulsa Building, Tulsa, Oklahoma.** Has 32 miles of 10-in. line between Magodore and Cleveland, Ohio, for Inland Corporation. Has 15 miles of 6-in. for *Freedom-Valvoline Oil Company* near Columbus, Ohio.

● **Texas Engineering & Construction Company, Amarillo, Texas.** Has undetermined amount of 4 through 12-in. natural gas gathering lines for *Colorado Interstate Gas Company* north of Amarillo, Texas.

● **Western Constructors, 101 Plymouth Life Building, Austin, Texas.** Has 80 miles of 30-in. natural gas line from Kinder, Louisiana, to Beaumont, Texas, for *Tennessee Gas Transmission Company*. Has 41 miles of 26 and 30-in. natural gas lines from Oxford, Colorado, to Governador, New Mexico, for *Pacific Northwest Pipeline Corporation*. Has 200 miles of 30-in. and 30 miles of 26-in. gas line starting in March for *American-Louisiana Pipe Line Company* commencing in southeast Louisiana to the Arkansas-Louisiana state line.

● **Williams Brothers Company, 326 National Bank of Tulsa Building, Tulsa, Oklahoma.** Has 108 miles of 10-in. coal pipe line from Georgetown to East Lake, Ohio.

● **H. B. Zachry Company, P. O. Box 2570, San Antonio 6, Texas.** Has 216 miles of 22-in. natural gas line between Burley, Idaho, and Ontario, Oregon, for *Pacific Northwest Pipeline Corporation*. Also has 42 miles of 4 through 16-in. natural gas lines for the same company near Aztec, New Mexico.

Shell Oil Begins Two New Projects

Work is now underway on two extensive Shell Oil Company projects for gathering natural gas and crude oil produced in offshore fields near the mouth of the Mississippi River, New Orleans exploration and production area officials have announced.

To end the flaring of natural gas, facilities capable of handling more than 30,000,000 cu ft of natural gas daily are being constructed at South Pass, Blocks 24 and 27, and Main Pass, Blocks 35 and 69.

In addition, a small natural gas project is underway at Halter Island near the mouth of the Atchafalaya River.

The plans call for Shell to spend nearly $4,000,000 on all the projects, to be completed next summer. Wells in these fields are now either shut in or their gas is being flared. A contract for the sale of this gas has been negotiated.

In the Block 24 and 27 fields gas-oil separators will be placed on nine existing production platforms. Twenty-five miles of intermediate and high pressure pipe lines will link the platforms with a 40 by 60 ft concrete compressor platform at the terminal. Elevated walkways will connect the compressor platform with two smaller raised platforms containing heaters and gas separators.

PROTECT OIL AND GAS PIPELINES *with* NICOLET ASBESTOS PIPELINE FELT

FIGHT PIPELINE CORROSION WITH ANY OF THESE NICOLET FELTS

- ★ Nicolet 15 lb. *Asbestos* Felt, Tar or Asphalt Saturated
- ★ Nicolet 15 lb. *Asbestos* Felt, parallel glass yarn reinforced, Tar or Asphalt Saturated
- ★ Nicolet 15 lb. *Asbestos* Felt, Perforated on Uniform Centers, Tar or Asphalt Saturated
- ★ Nicolet "Tufbestos" 8 lb. *Asbestos* Felt, reinforced with parallel glass yarns, Tar or Asphalt Saturated
- ★ Nicolet "Reflecto" 8 lb. or 10 lb. White Neoprene Treated *Asbestos* Felt, glass yarn reinforced

Asbestos is *inorganic*. We believe this *inorganic* material, which comprises the major contents of the base felt, provides a longer-lasting shield protection for all pipeline enamel coatings.

Write for your copy of the new Nicolet Catalog
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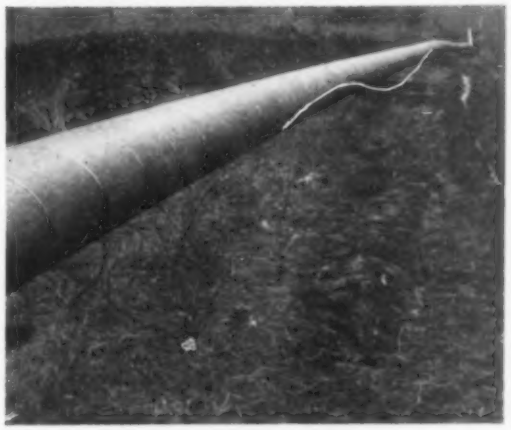

Photo showing Nicolet Felt Protecting Pipeline

The Felt With a Future

MANUFACTURED BY:
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NEW YORK 5, N. Y.

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NEW VERTICAL HYDRAULIC PIPE BENDING MACHINE

It's the **only vertical hydraulic** pipe bender in the business . . . designed to save you time and money on the line. It's lighter . . . more compact . . . and faster. Since it's not overweight, overheight or overwidth it can be easily and quickly transported on float truck without removal of tracks.

Two sizes: 16" through 30"; 22" through 36". Already proven in field on 36" line over rough terrain in Georgia and North Carolina. You must see the new Cinch Vertical Hydraulic Pipe Bending Machine in action to appreciate its time-cutting, money-saving benefits.

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Shell Pipe Line Buys System in New Mexico

Shell Pipe Line has purchased 85 miles of 2-to-8 in. gathering lines and 49 miles of 8-in. trunk line in Lea County, New Mexico from the Humble Pipe Line Company.

The change over took place January 1, 1956, and plans for interconnecting the Humble facilities with those of Shell Pipe Line are going ahead in the West Texas area.

The purchase of these properties will increase Shell's gatherings by some 6500 bbl per day and add millions of barrels of connected reserves to the system. Fields served by the Humble gathering system include: Bowers, Brunson, Cooper-Jal, Drinkard, Eunice-Monument, Eunice-South, Hobbs, Jalmat Gas Pool (formerly Cooper-Jal), Langlie-Mattix, Paddock and Penrose-Skelly. The 8-in. trunk line runs from Hobbs south to the Texas-New Mexico border and includes two main line pump stations located at Hobbs and Dublin.

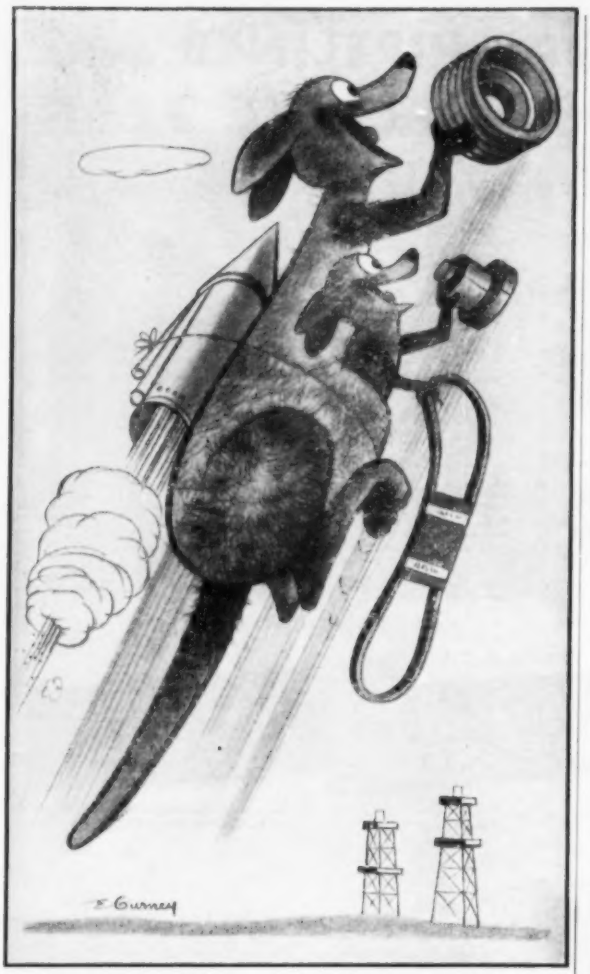
Plans call for dismantling two and a half miles of the 8-in. trunk line and relocating it to connect the Dublin Station with Shell Pipe Line and Basin Pipe Line facilities at the Jal Station.

Independent Oil Man Purchases Four Colorado and Kansas Systems

Ralph Murchison, Dallas, Texas, and a Colorado associate have announced the purchase of four Colorado and Kansas natural gas companies for $3,000,000.

The four firms, to be consolidated into the Plateau Natural Gas Company of Canon City, Colorado, are Kansas-Colorado Utilities, Pike's Peak Natural Gas Company, Midwest Natural Gas Company, and Goodland Natural Gas Company.

The distribution companies serve the communities of Lamar, Granada, Holly, Walsh, Springfield, Wiley, McClave, Bristol, Hartman, Vilas, Lyman, Hugo, Eads, Florence, Portland, Fountain and Castle Rock, Colorado, and Ulysses, Johnson, Syracuse, Kendall and Goodland, Kansas.



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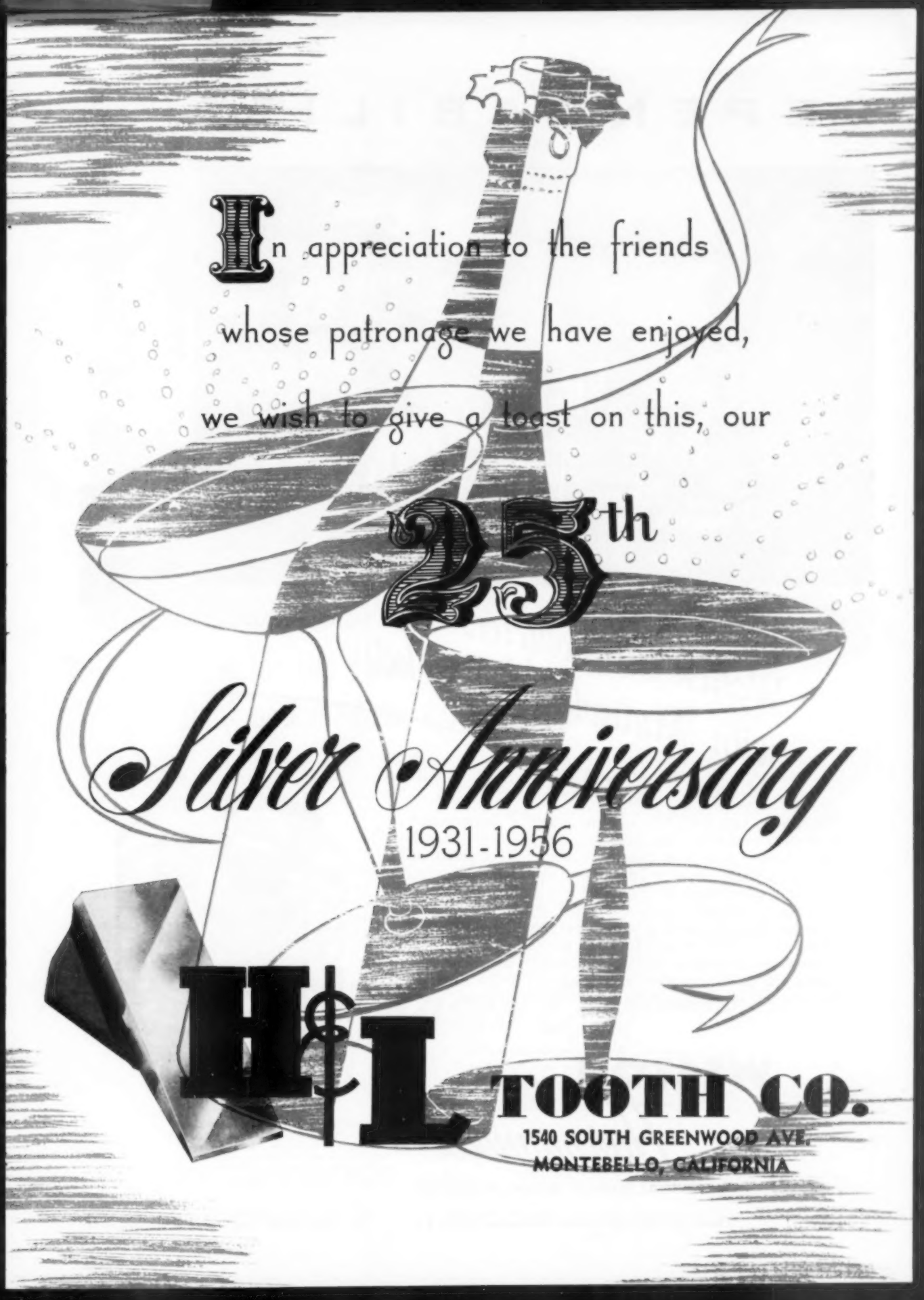
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whose patronage we have enjoyed,
we wish to give a toast on this, our
25th
Silver Anniversary
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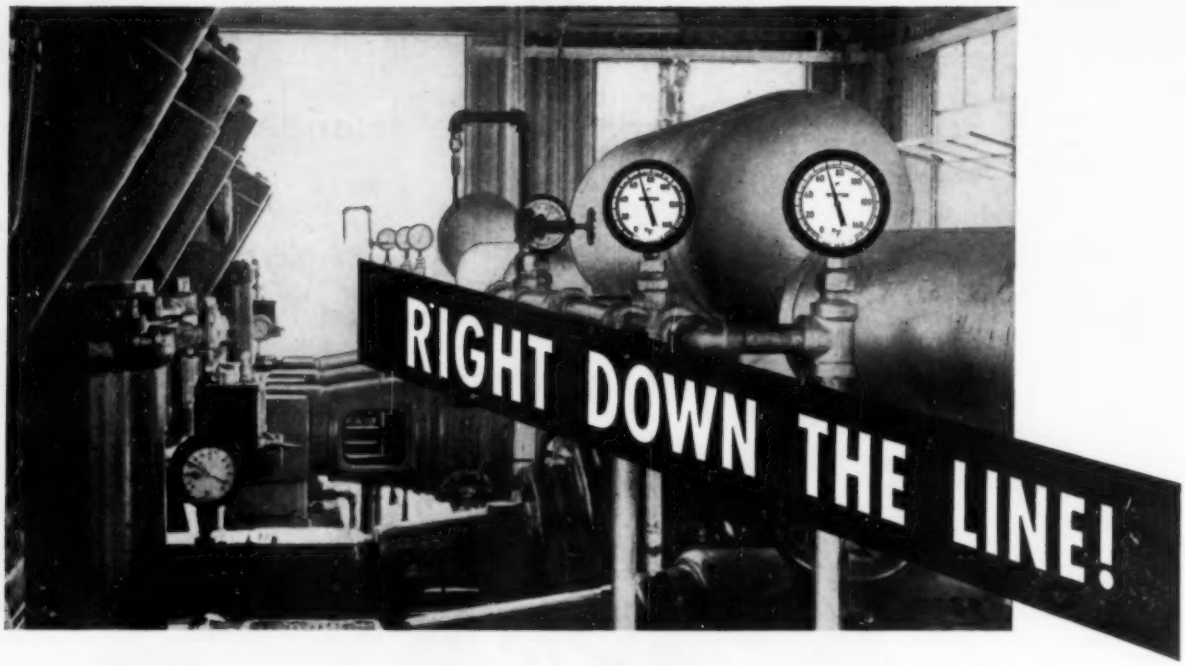
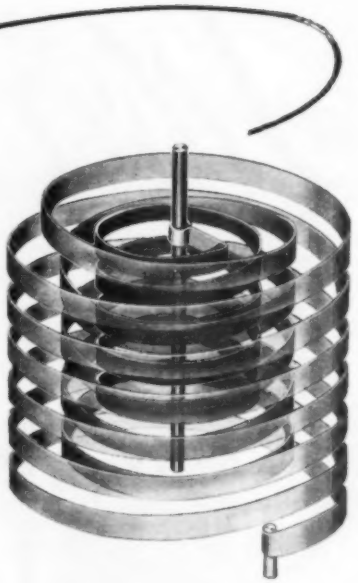
DEPENDABILITY



Weston thermometers with Multiple bimetal helix

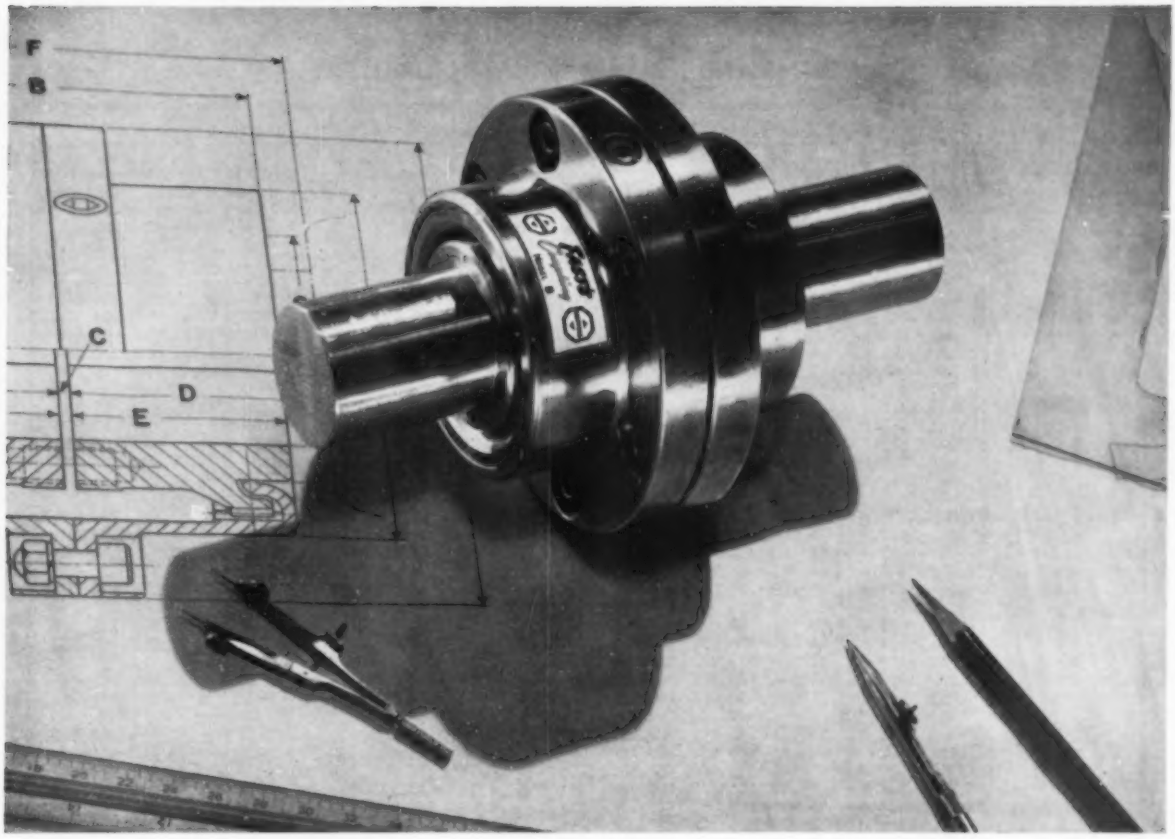
The reasons why WESTON all-metal industrial thermometers excel in dependability and long life . . . enjoy such outstanding preference throughout industry . . . stem in large part from Weston's exclusive design and manufacturing methods. The critical *sensing elements* are all Weston-made in the shorter *multiple helix* form to insure rugged, *nonsagging* units. They are then *cycle-seasoned,* over broad temperature ranges, to insure *consistently precise indications* over far longer periods. Thus they serve better, longer, at far lower over-all costs. Bulletin containing sizes, ranges and prices, available on request. WESTON Electrical Instrument Corporation, 614 Frelinghuysen Ave., Newark 5, N. J.



WESTON

Thermometers

AVAILABLE THROUGH LEADING DISTRIBUTORS



Now for the first time, a Fast's Coupling for light and medium drives—at a new low cost!

It's the new Fast's Coupling MODEL B—a lighter, smaller coupling with all the famous Fast's features never before available at such a low cost!

The new MODEL B fills the needs of manufacturers of fans, blowers, pumps and other light-to-medium drive units where coupling *cost* is as important as performance. Koppers engineers designed it to eliminate the cost barrier and offer Fast's rugged design and trouble-free performance for hundreds of new applications.

All steel, dust and moisture proof with metal-to-metal seal, Fast's MODEL B is available for shaft sizes up to $2\frac{5}{8}$". Like all Fast's Couplings, it's *sold with service* . . . Koppers *free* engineering service that guarantees the right coupling for the job.

The new Fast's MODEL B Coupling may offer a profitable solution to your light or medium drive coupling problems. Find out how by writing for full details to: KOPPERS COMPANY, INC., Fast's Coupling Dept., 261 Scott St., Baltimore 3, Md.

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Name.....

Company.....

Address.....

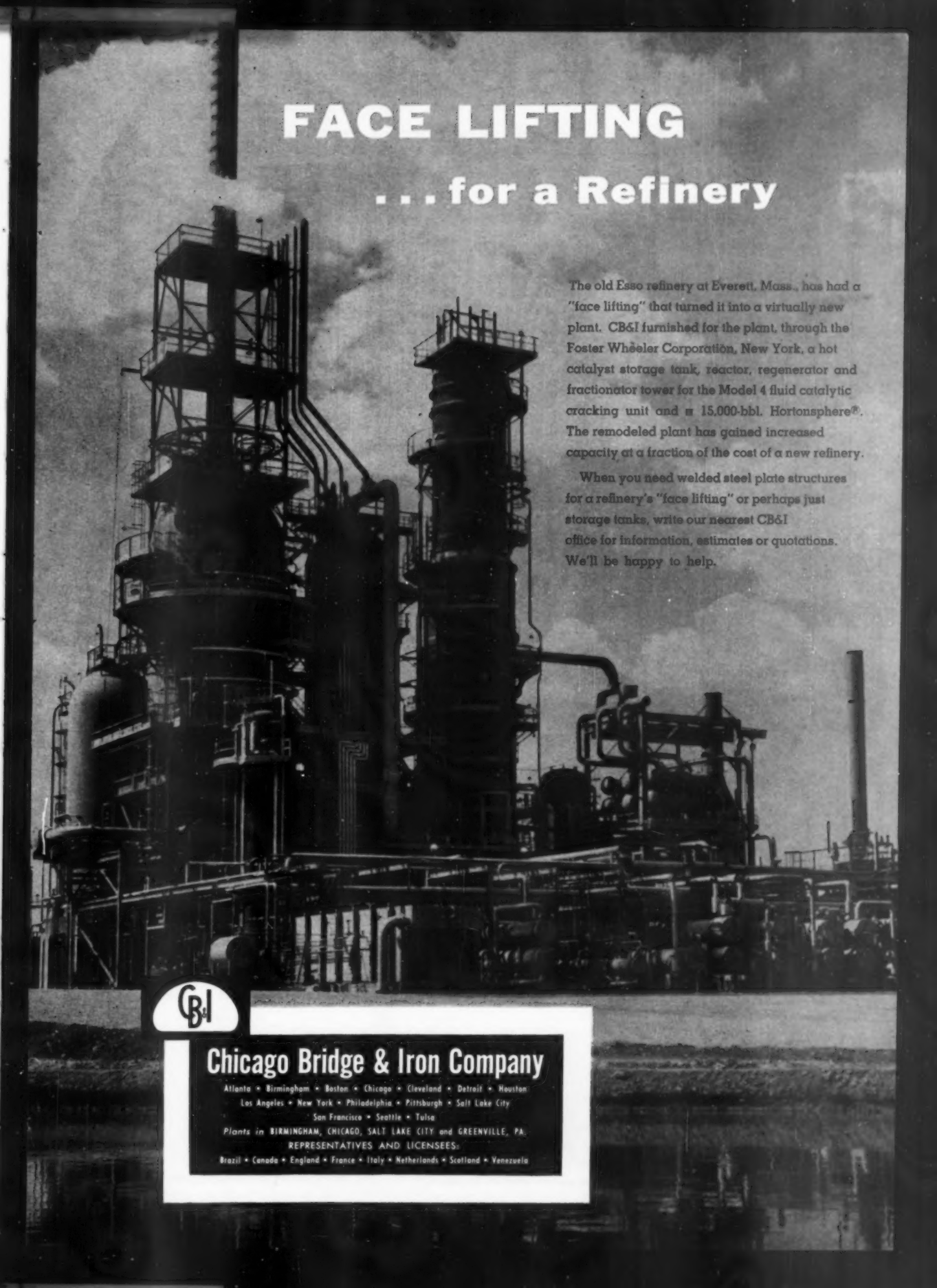
City.....Zone.....State.....

WEIGHT AND VOLUME OF 6⅝-IN. DRILL PIPE

Length of string of drill pipe ft.	22.2 lb. drill pipe				25.2 lb. drill pipe				31.9 lb. drill pipe			
	Weight, coupled,[1] lb.	Volume of fluid displaced, gal.	Weight of 9.5 lb./gal. fluid displaced, lb.	Net weight of drill pipe, lb.	Weight, coupled,[1] lb.	Volume of fluid displaced, gal.	Weight of 9.5 lb./gal. fluid displaced, lb.	Net weight of drill pipe, lb.	Weight, coupled,[1] lb.	Volume of fluid displaced, gal.	Weight of 9.5 lb./gal. fluid displaced, lb.	Net weight of drill pipe, lb.
2,000	44,400	678.4	6,445	37,955	50,400	770.2	7,315	43,085	63,800	975.0	9,260	54,540
2,200	48,840	746.2	7,090	41,750	55,440	847.2	8,050	47,390	70,180	1072.5	10,190	59,990
2,400	53,280	814.1	7,735	45,545	60,480	924.2	8,780	51,700	76,560	1170.0	11,115	65,445
2,600	57,720	881.9	8,380	49,340	65,520	1001.3	9,510	56,010	82,940	1267.5	12,040	70,900
2,800	62,160	949.8	9,025	53,135	70,560	1078.3	10,245	60,315	89,320	1365.0	12,970	76,350
3,000	66,600	1017.6	9,665	56,935	75,600	1155.3	10,975	64,625	95,700	1462.5	13,895	81,805
3,200	71,040	1085.4	10,310	60,730	80,640	1232.3	11,705	68,935	102,080	1560.0	14,820	87,260
3,400	75,480	1153.3	10,955	64,525	85,680	1309.3	12,440	73,240	108,460	1657.5	15,745	92,715
3,600	79,920	1221.1	11,600	68,320	90,720	1386.4	13,170	77,550	114,840	1755.0	16,670	98,170
3,800	84,360	1289.0	12,245	72,115	95,760	1463.4	13,900	81,860	121,220	1852.5	17,600	103,620
4,000	88,800	1356.8	12,890	75,910	100,800	1540.4	14,635	86,165	127,600	1950.0	18,525	109,075
4,200	93,240	1424.6	13,535	79,705	105,840	1617.4	15,365	90,475	133,980	2047.5	19,450	114,530
4,400	97,680	1492.5	14,180	83,500	110,880	1694.4	16,095	94,785	140,360	2145.0	20,380	119 980
4,600	102,120	1560.3	14,825	87,295	115,920	1771.5	16,830	99,090	146,740	2242.5	21,305	125,435
4,800	106,560	1628.2	15,470	91,090	120,960	1848.5	17,560	103,400	153,120	2340.0	22,230	130,890
5,000	111,000	1696.0	16,110	94,890	126,000	1925.5	18,290	107,710	159,500	2437.5	23,155	136,345
5,200	115,440	1763.8	16,755	98,685	131,040	2002.5	19,025	112,015	165,880	2535.0	24,080	141,800
5,400	119,880	1831.7	17,400	102,480	136,080	2079.5	19,755	116,325	172,260	2632.5	25,010	147,250
5,600	124,320	1899.5	18,045	106,275	141,120	2156.6	20,485	120,635	178,640	2730.0	25,935	152,705
5,800	128,760	1967.4	18,690	110,070	146,160	2233.6	21,220	124,940	185,020	2827.5	26,860	158,160
6,000	133,200	2035.2	19,335	113,865	151,200	2310.6	21,950	129,250	191,400	2925.0	27,790	163,610
6,200	137,640	2103.0	19,980	117,660	156,240	2387.6	22,680	133,560	197,780	3022.5	28,715	169,065
6,400	142,080	2170.9	20,625	121,455	161,280	2464.6	23,415	137,865	204,160	3120.0	29,640	174,520
6,600	146,520	2238.7	21,270	125,250	166,320	2541.7	24,145	142,175	210,540	3217.5	30,565	179,975
6,800	150,960	2306.6	21,910	129,050	171,360	2618.7	24,875	146,485	216,920	3315.0	31,490	185,430
7,000	155,400	2374.4	22,555	132,845	176,400	2695.7	25,610	150,790	223,300	3412.5	32,420	190,880
7,200	159,840	2442.2	23,200	136,640	181,440	2772.7	26,340	155,100	229,680	3510.0	33,345	196,335
7,400	164,280	2510.1	23,845	140,435	186,480	2849.7	27,075	159,405	236,060	3607.5	34,270	201,790
7,600	168,720	2577.9	24,490	144,230	191,520	2926.8	27,805	163,715	242,440	3705.0	35,200	207,240
7,800	173,160	2645.8	25,135	148,025	196,560	3003.8	28,535	168,025	248,820	3802.5	36,125	212,695
8,000	177,600	2713.6	25,780	151,820	201,600	3080.8	29,270	172,330	255,200	3900.0	37,050	218,150
8,200	182,040	2781.4	26,425	155,615	206,640	3157.8	30,000	176,640	261,580	3997.5	37,975	223,605
8,400	186,480	2849.3	27,070	159,410	211,680	3234.8	30,730	180,950	267,960	4095.0	38,900	229,060
8,600	190,920	2917.1	27,715	163,205	216,720	3311.9	31,465	185,255	274,340	4192.5	39,830	234,510
8,800	195,360	2985.0	28,355	167,005	221,760	3388.9	32,195	189,565	280,720	4290.0	40,755	239,965
9,000	199,800	3052.8	29,000	170,800	226,800	3465.9	32,925	193,875	287,100	4387.5	41,680	245,420
9,200	204,240	3120.6	29,645	174,595	231,840	3542.9	33,660	198,180	293,480	4485.0	42,610	250,870
9,400	208,680	3188.5	30,290	178,390	236,880	3619.9	34,390	202,490	299,860	4582.5	43,535	256,325
9,600	213,120	3256.3	30,935	182,185	241,920	697.0	35,120	206,800	306,240	4680.0	44,460	261,780
9,800	217,560	3324.2	31,580	185,980	246,960	3774.0	35,855	211,105	312,620	4777.5	45,385	267,235
10,000	222,000	3392.0	32,225	189,775	252,000	3851.0	36,585	215,415	319,000	4875.0	46,310	272,690
10,200	226,440	3459.8	32,870	193,570	257,040	3928.0	37,315	219,725	325,380	4972.5	47,240	278,140
10,400	230,880	3527.7	33,515	197,365	262,080	4005.0	38,050	224,030	331,760	5070.0	48,165	283,595
10,600	235,320	3595.5	34,155	201,165	267,120	4082.1	38,780	228,340	338,140	5167.5	49,090	289,050
10,800	239,760	3663.4	34,800	204,960	272,160	4159.1	39,510	232,650	344,520	5265.0	50,020	294,500
11,000	244,200	3731.2	35,445	208,755	277,200	4236.1	40,245	236,955	350,900	5362.5	50,945	299,955
11,200	248,640	3799.0	36,090	212,550	282,240	4313.1	40,975	241 265	357,280	5460.0	51,870	305,410
11,400	253,080	3866.9	36,735	216,345	287,280	4390.1	41,705	245,575	363,660	5557.5	52,795	310,865
11,600	257,520	3934.7	37,380	220,140	292,320	4467.2	42,440	249,880	370,040	5655.0	53,720	316,320
11,800	261,960	4002.6	38,025	223,935	297,360	4544.2	43,170	254,190	376,420	5752.5	54,650	321,770
12,000	266,400	4070.4	38,670	227,730	302,400	4621.2	43,900	258,500	382,800	5850.0	55,575	327,225
12,200	270,840	4138.2	39,315	231,525	307,440	4698.2	44,635	262,805	389,180	5947.5	56,500	332,680
12,400	275,280	4206.1	39,960	235,320	312,480	4775.2	45,365	267,115	395,560	6045.0	57,430	338,130
12,600	279,720	4273.9	40,600	239,120	317,520	4852.3	46,095	271,425	401,940	6142.5	58,355	343,585
12,800	284,160	4341.8	41,245	242,915	322,560	4929.3	46,830	275,730	408,320	6240.0	59,280	349,040
13,000	288,600	4409.6	41,890	246,710	327,600	5006.3	47,560	280,040	414,700	6337.5	60,205	354,495

[1]If a regular tool joint is inserted every 90 ft. all values for 22.2-lb. drill pipe will be increased about 4.0 percent, for 25.2-lb. drill pipe about 3.5 percent, and for 31.9-lb. drill pipe about 2.4 percent.

To obtain more information on products advertised see page E-41



FACE LIFTING

. . . for a Refinery

The old Esso refinery at Everett, Mass., has had a "face lifting" that turned it into a virtually new plant. CB&I furnished for the plant, through the Foster Wheeler Corporation, New York, a hot catalyst storage tank, reactor, regenerator and fractionator tower for the Model 4 fluid catalytic cracking unit and a 15,000-bbl. Hortonsphere®. The remodeled plant has gained increased capacity at a fraction of the cost of a new refinery.

When you need welded steel plate structures for a refinery's "face lifting" or perhaps just storage tanks, write our nearest CB&I office for information, estimates or quotations. We'll be happy to help.

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HYDROCHLORIC ACID—PHYSICAL PROPERTIES OF AQUEOUS SOLUTION

Be.°	Specific gravity at 60°F./60°F.	Percent HCl	Wt. in lb. per gal. at 60°F./60°F.	Gal. equivalent to 1 gal. of 15 percent HCl	Gal. of 15 percent HCl equivalent to 1 gal	Gal. of 15 percent HCl equivalent to 1 lb.
14.00	1.1069	21.27	9.2280	0.68489	1.46008	0.15822
14.25	1.1090	21.68	9.2455	0.67067	1.49105	0.16127
14.45	1.1106	22.00	9.2589	0.65996	1.51524	0.16365
14.50	1.1111	22.09	9.2630	0.65698	1.52212	0.16432
14.75	1.1132	22.50	9.2805	0.64379	1.55330	0.16737
15.00	1.1154	22.92	9.2989	0.63075	1.58542	0.17050
15.05	1.1158	23.00	9.3022	0.62833	1.59153	0.17109
15.25	1.1176	23.33	9.3172	0.61844	1.61697	0.17355
15.50	1.1197	23.75	9.3347	0.60637	1.64917	0.17667
15.65	1.1210	24.00	9.3456	0.59935	1.66847	0.17853
15.75	1.1219	24.16	9.3531	0.59491	1.68093	0.17972
16.0	1.1240	24.57	9.3706	0.58389	1.71266	0.18277
16.1	1.1248	24.73	9.3772	0.57970	1.72504	0.18396
16.2	1.1256	24.90	9.3839	0.57533	1.73814	0.18523
16.26	1.1262	25.00	9.3889	0.57272	1.74605	0.18597
16.3	1.1265	25.06	9.3914	0.57120	1.75070	0.18642
16.4	1.1274	25.23	9.3989	0.56690	1.76399	0.18768
16.5	1.1283	25.39	9.4064	0.56288	1.77659	0.18887
16.6	1.1292	25.56	9.4139	0.55869	1.78991	0.19014
16.7	1.1301	25.72	9.4214	0.55477	1.80255	0.19133
16.8	1.1310	25.89	9.4289	0.55069	1.81591	0.19259
16.87	1.1316	26.00	9.4339	0.54807	1.82458	0.19341
16.9	1.1319	26.05	9.4364	0.54687	1.82859	0.19378
17.0	1.1328	26.22	9.4439	0.54289	1.84199	0.19505
17.1	1.1336	26.39	9.4506	0.53901	1.85524	0.19631
17.2	1.1345	26.56	9.4581	0.53514	1.86867	0.19757
17.3	1.1354	26.73	9.4656	0.53131	1.88212	0.19884
17.4	1.1363	26.90	9.4731	0.52754	1.89559	0.20010
17.46	1.1368	27.00	9.4773	0.52535	1.90348	0.20085
17.5	1.1372	27.07	9.4806	0.52381	1.90909	0.20137
17.6	1.1381	27.24	9.4881	0.52013	1.92259	0.20263
17.7	1.1390	27.41	9.4956	0.51650	1.93612	0.20390
17.8	1.1399	27.58	9.5031	0.51291	1.94967	0.20516
17.9	1.1408	27.75	9.5106	0.50936	1.96324	0.20643
18.0	1.1417	27.92	9.5181	0.50586	1.97682	0.20769
18.05	1.1421	28.00	9.5215	0.50424	1.98318	0.20829
18.1	1.1426	28.09	9.5256	0.50240	1.99043	0.20896
18.2	1.1435	28.26	9.5331	0.49899	2.00405	0.21022
18.3	1.1444	28.44	9.5406	0.49544	2.01840	0.21156
18.4	1.1453	28.61	9.5481	0.49211	2.03206	0.21282
18.5	1.1462	28.78	9.5556	0.48882	2.04575	0.21409
18.6	1.1471	28.95	9.5631	0.48557	2.05945	0.21535
18.63	1.14735	29.00	9.5652	0.48462	2.06345	0.21573
18.7	1.1480	29.13	9.5706	0.48219	2.07388	0.21669
18.8	1.1489	29.30	9.5781	0.47902	2.08761	0.21796
18.9	1.1498	29.48	9.5857	0.47572	2.10208	0.21930
19.0	1.1508	29.65	9.5940	0.47258	2.11604	0.22056
19.1	1.1517	29.83	9.6015	0.46936	2.13056	0.22190
19.2	1.1526	30.00	9.6090	0.46634	2.14437	0.22316
19.3	1.1535	30.18	9.6165	0.46319	2.15892	0.22450
19.4	1.1544	30.35	9.6240	0.46024	2.17278	0.22577
19.5	1.1554	30.53	9.6323	0.45713	2.18756	0.22711
19.6	1.1563	30.71	9.6398	0.45410	2.20217	0.22845
19.7	1.1572	30.90	9.6473	0.45095	2.21752	0.22986
19.76	1.1577	31.00	9.6515	0.44931	2.22566	0.23060
19.8	1.1581	31.08	9.6548	0.44799	2.23217	0.23120
19.9	1.1590	31.27	9.6624	0.44493	2.24756	0.23261

Be.° Specific Gravity at $\frac{60°\text{ F.}}{60°\text{ F.}}$ and percent HCl taken from HCl table in *Handbook of Chemistry and Physics*.

Weight in lb. per gal. at $\frac{60°\text{ F.}}{60°\text{ F.}} = 8.3368 \times \text{sp. gr.}$

Gal. equivalent to 1 gal. of 15 percent HCl $= \dfrac{0.16125}{\text{sp. gr.} \times \dfrac{\text{percent HCl}}{100}}$

Gal. of 15 percent HCl equivalent to 1 gal. $= \dfrac{1}{\dfrac{0.16125}{\text{sp. gr.} \times \dfrac{\text{percent HCl}}{100}}}$

Gal. of 15 percent HCl equivalent to 1 lb $= \dfrac{\text{percent HCl}}{100 \times 1.3443} = \dfrac{\text{percent HCl}}{134.43}$

This series of tables submitted by Dowell Incorporated, Tulsa, Oklahoma

To obtain more information on products advertised see page E-41

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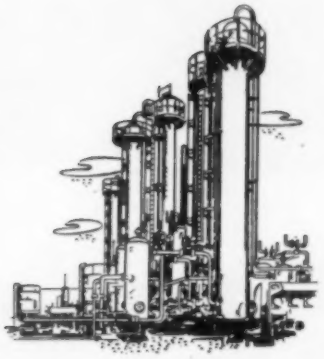
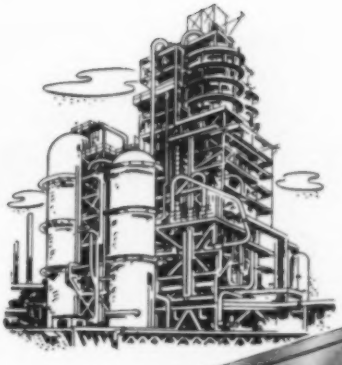


• This record rail load for length, 192 feet, was Fabricated in Wyatt's Houston Plant for Oil Refining Service on the Gulf Coast



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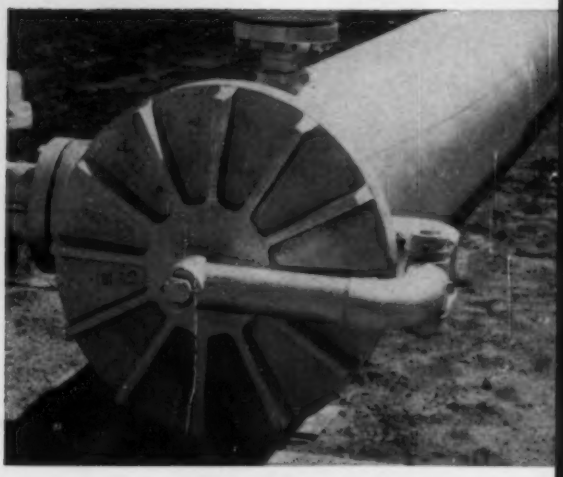

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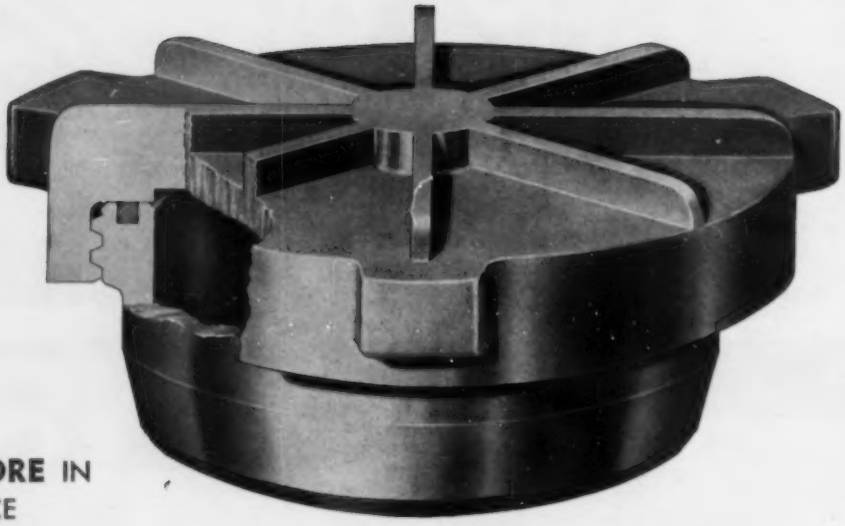

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Modern Genii of the American Motorist

ADDITIVES

Automatic transmission, power brakes and steering, and other engineering advances demand new products that require new chemicals — to the tune of a million barrels a year

Wayne E. Kuhn and John W. Hutcheson

ONE OF THE TEST locations where Texaco's premium gasoline was tested in 26 new cars on a mesquite-lined highway outside San Antonio, Texas.

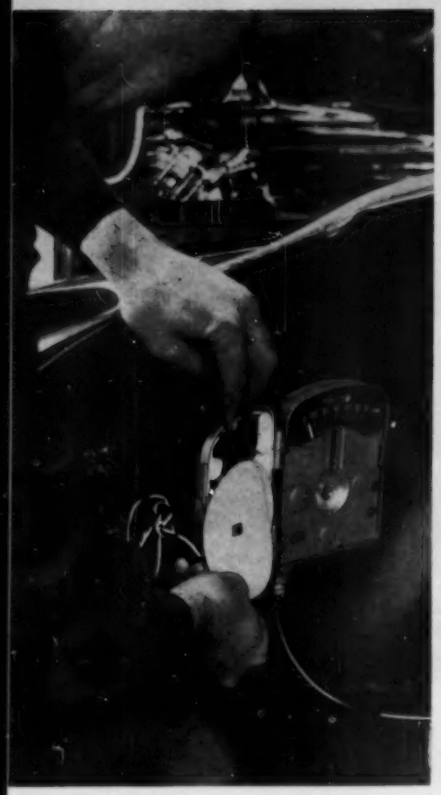
DEMANDS of the American motorist have created an important chemicals market. Going about the familiar routines of buying gasoline, getting a grease job, or having his oil changed, the car owner has become a significant figure in shaping new end uses for chemical products. He has provided the spur for the amazing increase in the use of chemical components in petroleum automotive products. Further, his demands have impelled the remarkable growth of a new "hidden" enterprise, the additives business, which may now be nearing $500,000,000 a year in sales.

The growth in use of chemical components in petroleum motoring products is clearly shown in comparative motor oil additive figures for the years 1941 and 1955 (estimated). First, the dollar growth: The powerful, high-compression-ratio passenger automobiles which a large percentage of the country's 50,000,000 car owners drive are now consuming more than $100,000,000 worth of crankcase oil additives a year. This is more than 20 times the consumption figure of 1941. Second, the volume growth: In 1941, 45,000 bbl of motor oil additives were processed. This year, motorists will consume in excess of 1,000,000 bbl in their crankcases.

A TEST FLEET lines up at masked fuel pumps to fill up for a night speed run. Cars were driven 16 hours daily for 700,000 miles in this particular test run.

The additives industry has grown up within the matrix of the petroleum and chemicals industries and has thus remained obscured from the public. Its rapid rise signalizes the broadening base of its parent industries. Perhaps the simplest way to get at the story of the additives business is to start with the basic persuader in any market place: **Consumer demand.** This article will sketch roughly the profile of the new market, detail some significant end-use statistics, and provide an estimate of future volumes.

The pressures of consumer demand are imperative in technological progress. The American motorist is never satisfied. He wants something new, and he wants something better. Above all, he wants the new and the better **right now.** Today he has the money to fortify his demand. Hence, the swiftness of change since World War II in automotive power plants and auxiliary equipment, and the rapid progress in the development of new fuels, oils, greases, and special fluids used in the modern car.



THE ROAD TEST. Precise speed records were kept by a special speedometer in the trunk compartment to record data.

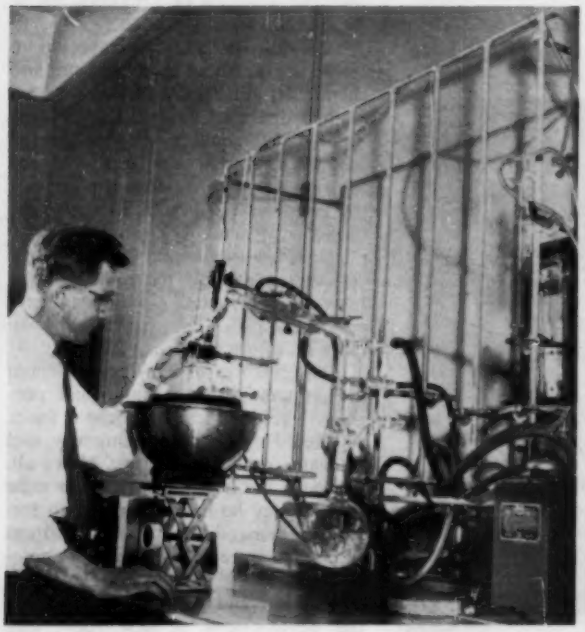
Power steering is a familiar example of new technology. This is an improvement the average motorist immediately recognizes. There is another aspect of improved technology, however, which the public does not see — the new day-to-day operating problems which follow immediately on the heels of progress. We might ask several questions to get at the nature of these new problems. For example, what happened in automotive design that caused additives to show up all over the family car? (Notice that the accompanying schematic chassis diagram shows thirteen locations where chemical components are in use in many cars). And also, why couldn't the old-style motoring products do their jobs any more?

The key to the changes which have taken place is the word **job.** Today, a product may be called upon to perform an entirely different type of job from its predecessor product of several decades ago. As automotive mechanisms have become more complicated, and operating conditions more severe, new requirements have evolved which call for new products. These must afford efficient performance under conditions which require properties and materials other than those previously found in motoring products.

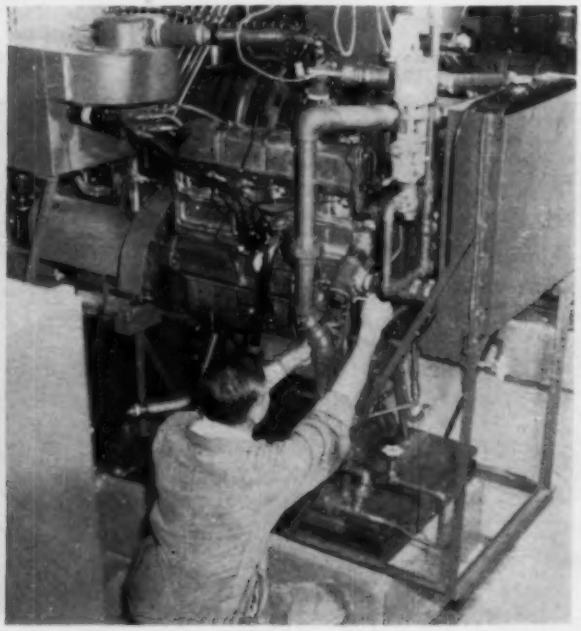
For example, the transmission lubricant used by car owners before the advent of automatic transmissions could not function in the new mechanisms. This is an instance where the petroleum industry found itself coping, not with an aggravated problem, but with an entirely new type of problem. It is fair to say that improved technology created new **classes** of problems, many of which had to be defined through consumer experience and extraordinary laboratory and road test programs.

Additives, both in the form of chemical compounds and mixtures, were called upon in greater frequency and greater volume to enhance the inherent properties of petroleum products or to impart new properties. Although the great increase in the use of these chemical components started about 1940, additives were not entirely foreign to earlier products. Tetraethyl lead has been added commercially to gasoline since 1923.

Increasing severity of operating conditions can best be illustrated by the upward trend of that popular symbol of engine progress — the compression ratio. It is axiomatic that to maintain pressure you must have as nearly perfect closure as is possible. Therefore, higher compression ratio engines demand more perfect closures in the combustion chamber, perfectly seated seals, and closer tolerances. Deposition becomes a more critical problem, as does wear. The attrition of exhaust gas and fine-particle products of combustion rushing by at tremendous speed and very high temperatures creates a severe wear problem for exhaust valves. Deposits on valve seats or on the tulip of the valve might prevent a tight seal on the intake and compression strokes. Deposition on the valve stem might hang up the valve in the valve guide and prevent efficient closure. These problems become increasingly critical as compression ratios increase. Therefore, the fuel must have properties which effectively



AT THE LABORATORY. Here an additive is synthesized to be used in an experimental engine oil.



Sample of coolant is drained from an engine after a test in the lab on an experimental anti-freeze.

limit deposition and its attendant effects.

Inasmuch as compression ratio plays a critical part in the use and formulation of additives in gasoline, it might be useful briefly to review its short history in automobile engines in this country. Until World War I, compression ratio in any year rarely averaged more than 3 to 1. At the time tetraethyl lead came into use, the average was about 3.5 to 1. In the first 6 years — 1924 to 1930 — that the new additive was in use, compression ratios increased to an average of 5.1 to 1. Between 1930 and 1942 the average increased to 6.6 to 1 where it remained during World War II. The post-war rise began with the 1948 models. Here are year-by-year averages since then:

1948	6.73 to 1
1949	6.88 to 1
1950	7.03 to 1
1951	7.07 to 1
1952	7.18 to 1
1953	7.44 to 1
1954	7.64 to 1
1955	7.96 to 1

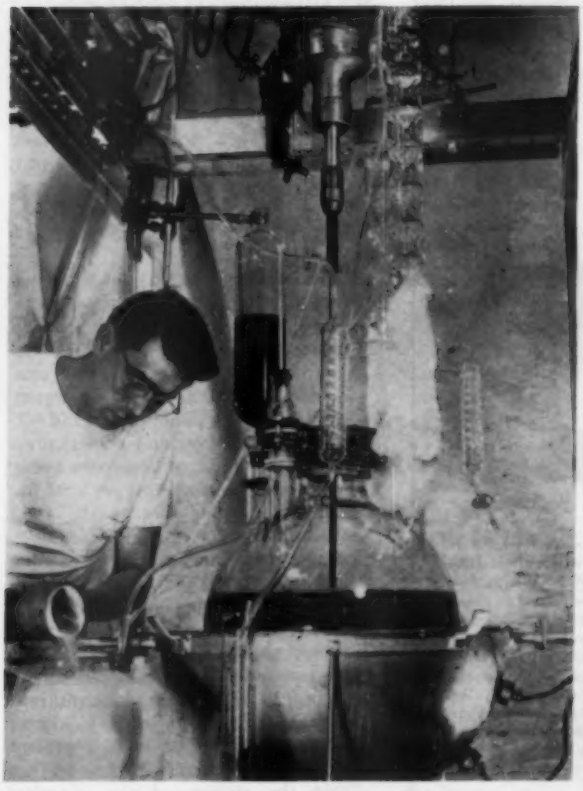
Currently, the highest compression ratio in a 1955 production model automobile engine is 9.00 to 1.

The Texas Company, like other refiners, has undertaken to formulate a premium grade gasoline, which through the judicious use of additive materials, will afford the most efficient possible combustion and power conversion. The Texas Company has chosen to utilize an exclusive non-metallic material derived from petroleum to impart to its Sky Chief motor gasoline special properties which function effectively without promoting dubious side effects. The material is called Petrox from its petrochemical origins.

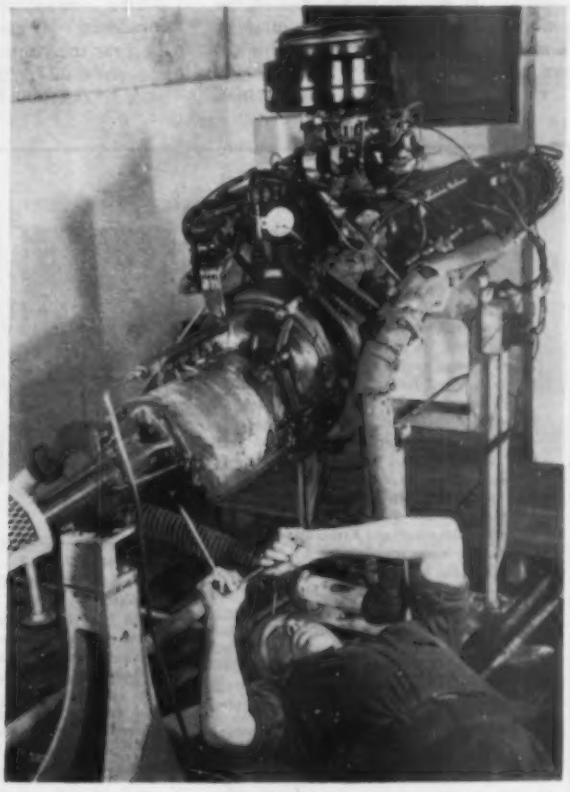
The engine oil must also promote the most efficient output of power under the adverse operating conditions caused by increased compression ratios. The refiner now blends highly specialized chemical components into a refined mineral oil stock to produce a new type of engine oil with properties unknown to predecessor products. A premium grade engine oil now contains additives which provide users with the following benefits: Heavy duty protection, detergency, extreme pressure protection, foam prevention, rust protection, continuous dispersion of dirt particles, protection against undue viscosity change under any operating conditions in any type of weather, protection against corrosion, and decreased deposition in the combustion chamber.

In addition, the chemical components in this oil provide these additional indirect benefits to the motorist: The product can be packaged, shipped, and

ON THE ROAD. Octane requirement of each new car is determined at intervals by using calibrated fuels as shown above.



LABORATORY TESTS. Petrochemical additive compound is prepared in Beacon Laboratories of Texaco.



Hydra-matic transmission is adjusted before a test of automatic transmission fluid.

stored without any change in quality. Such a product is formulated to enable the car owner to get all the power he pays for in the automobile showroom. It is truly tailored, component by component, for the critical needs of the modern high compression engine.

In addition to automatic transmission fluid, gasoline, and engine oil, another motoring product, radiator fluid, has contributed greatly to the increased consumption of chemical components by the car owner.

The table accompanying this article needs a few words of explanation. The base year selected was 1953 because that was the threshhold year for certain important changes which, in the face of presently incomplete data, cannot accurately be measured. Power steering and the tremendous growth of gasoline additive use were just getting started. It will take years to separate such highly competitive volumes as the wholly hydrocarbon-derived type vs. the organic salt type of additive in fuels. Thus, 1953 stands as a useful baseline.

The accompanying data are based on use figures of chemical components present in a statistically "typical" automobile. The basic annual consumption unit is 1000 automobiles, a convenient aggregate which was established because a single car might in a year show only "trace" quantities of a material. It will be noted that in the case of some materials a trace quantity is all that can be measured for the entire census.

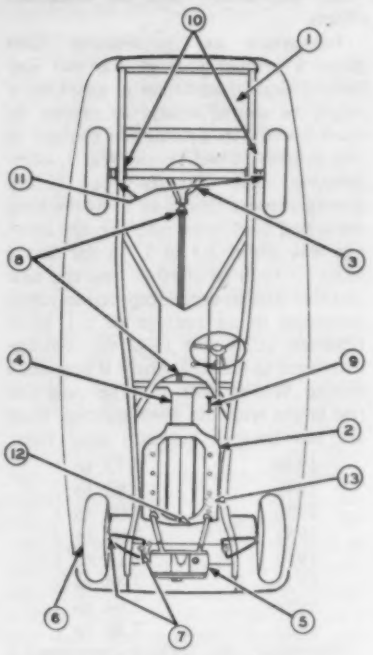
Certain chemical components have been analyzed in terms of 100 per cent use for statistical purposes only. Thus, in estimating the use of additives in automatic transmission fluids, it is assumed that all cars have automatic transmissions. Likewise, in developing figures for standard transmissions, it is assumed that all cars use standard transmissions. It is not presently practicable to try to separate the automatic and standard transmission census and resultant statistics on chemical components.

Similarly, the chemical components ethylene glycol and methanol are each shown to be in use 100 per cent. Until authentic competitive sales figures are available for these two anti-freeze materials, it will be impossible to make accurate estimates of the proportions of the market each enjoys. (We do know that ethylene glycol production has increased rapidly during the spectacular post-war growth of the petrochemical industry.)

The statistics presented here are impressive evidence of the importance of chemical components in motoring products. Here the additives man, whether he is with a petroleum company, a chemicals company, or a company specializing in additives manufacture, can measure his contributions to better motoring.

This is the x-ray of a relatively new chemicals market:

The average automobile in 1953 consumed 660 gal of gasoline. During the year the country's 46,460,000 cars consumed 222,920,000 lb of tetraethyl lead, 65,600,000 lb of ethylene dibromide, 69,780,000 lb of ethylene dichloride, 7,340,000 lb of dye, and 10,270,000 lb of gum inhibitor. Total additive consumption in gasoline was 375,910,000 lb. Additional gasoline additives introduced in some markets in 1953 (one a wholly hydrocarbon-derived material, others containing organic salts) and on a nationwide basis later, are not included. They are shown, however, in the 1960 projection, each with 100 per cent usage, it being too early to proportion the future market of these relatively new materials.



SEE CHART AT RIGHT
Position numbers are in Column One.

The average car in 1953 carried 5.1 qt of engine oil in its crankcase. Assuming recommended oil change rates and allowing for make-up between changes, all cars that year consumed 137,750,000 lb of detergent, 91,800,000 lb of inhibitor, 85,250,000 lb of V. I. improver and pour depressant, and 26,000 lb of anti-foam agent. These figures assume 100 per cent use of fortified engine oils by the 1953 registration.

An average automatic transmission carries 11 qt of fluid. If all cars had been equipped with automatic transmissions in 1953, and had no additions or change of fluid, they would have consumed 18,580,000 lb of detergent, 37,170,000 lb of sulfurized material, 9,290,000 lb of inhibitor, and 37,170,000 lb of V. I. improver.

One more citation will suffice to indicate the stature of the chemical components market in 1953:

The Authors

Dr. Wayne E. Kuhn is general manager of the Research and Technical Department of The Texas Company. After receiving a BA degree in science from Reed College in Portland, Oregon, in 1925, Kuhn was awarded a PhD in chemistry from Cornell in 1929. He entered the service of The Texas Company in 1929, as a chemist at Bayonne, New Jersey.

His memberships include API, ASTM, American Chemical Society, Society of Automotive Engineers, The American Institute of Chemists, American Institute of Physics, American Association for the Advancement of Science, Chemical Society of London, Institute of Petroleum, Commercial Chemical Development Association, and Coordinating Research Council.

In 1950 Dr. Kuhn was awarded the Honor Scroll of the New York Chapter of the American Institute of Chemists. In November, 1953 the American Petroleum Institute awarded Dr. Kuhn a Certificate of Appreciation "in acknowledgment of meritorious service to the petroleum industry through his participation in work of the Institute."

John W. Hutcheson is the project leader of Market and Utilization Studies in the Chemicals Research Department at The Texas Company's main research center in Beacon, New York. A native of Missouri, he received his BA from Central College, Fayette, Missouri, in 1939 and an MS in chemistry in 1941 from Oklahoma A & M.

Hutcheson and Kuhn were authors of a paper, "Ethylene Petrochemicals, Today and Tomorrow," presented before the National Petroleum Association in 1951. This paper for the first time assessed the character and growth of the petrochemicals industry, and predicted the future course of growth.

W. E. Kuhn

J. W. Hutcheson

CHART 1. CHEMICAL USE IN PASSENGER CARS GROWING

← DIAGRAM Position No.	Location	Petroleum product	Typical amount present in a car	Chemical component	1953 Amount of chemicals in 1000 cars lb	1953 Yearly requirement for 1000 cars lb.	1953 Yearly requirement for 46,460,000 cars million lb.	1960 Amount of chemicals in 1000 cars lb.	1960 Yearly requirement for 1000 cars lb.	1960 Yearly requirement for 58,000,000 cars million lb.
1	Gasoline tank	Gasoline	18 gal.	Tetraethyl lead	130.9	4,798	222.92	130.9	4,798	278.28
				Ethylene dibromide	38.5	1,412	65.60	38.5	1,412	81.90
				Ethylene dichloride	41.0	1,502	69.78	41.0	1,502	87.12
				Dye	4.3	158	7.34	4.3	158	9.17
				Gum inhibitor	6.0	221	10.27	6.0	221	12.82
				Organic salt additive[6] or	—	—	—	26.6	879.1	50.99
				Nonmetallic additive[9]	—	—	—	6.80	224.5	13.02
2	Crankcase	Heavy duty motor oil (SAE 20)	5.1 qt.	Detergent[1]	210.0	2,965	137.75	210.0	2,965	171.97
				Inhibitor[2]	140.0	1,976	91.80	140.0	1,976	114.61
				V.I. improver[3] and pour depressant[4]	130.0	1,835	85.25	130.0	1,835	106.43
				Antifoam agent[5]	0.04	0.56	0.026	0.04	0.56	0.03
3	Differential	Gear lubricant	3.5 pt.	E.P. agent[6]	300.0	300.0	13.94	330.0	330.0	19.14
				V.I. improver[3]	16.0	16.0	0.74	16.0	16.0	0.93
				Antifoam agent[5]	Trace	Trace	Trace	Trace	Trace	Trace
4	Standard transmission	Standard transmission lubricant or	2.5 pt.	E.P. agent[6]	210.0	210.0	9.76	210.0	210.0	12.18
				V.I. improver[3]	10.0	10.0	0.46	10.0	10.0	0.58
				Antifoam agent[5]	Trace	Trace	Trace	Trace	Trace	Trace
	Automatic transmission	Automatic transmission fluid	11 qt.	Detergent[1]	400.0	400.0[10]	18.58	400.0	400.0	23.20
				Sulfurized material	800.0	800.0[10]	37.17	800.0	800.0	46.40
				Inhibitor[2]	200.0	200.0[10]	9.29	200.0	200.0	11.60
				V.I. improver[3]	800.0	800.0[10]	37.17	800.0	800.0	46.40
5	Cooling system	Permanent type antifreeze or	21 qt.	Ethylene glycol	18,500	18,500	859.51	18,500	18,500	1073.00
				Corrosion inhibitor	600	600	27.88	600	600	34.80
		Alcohol type antifreeze solution	21 qt.	Methanol	13,900	13,900	645.79	13,900	13,900	806.20
				Inhibitor	120	120	5.58	120	120	6.96
6	Wheels	Wheel-bearing grease	6 oz./ wheel/ year	Metal soap[7]	Small	165.0	7.67	Small	165.0	9.57
7	Chassis fittings	Chassis lubricant	0.25 to 0.5 lb.	Metal soap[7]	25 to 50	225–450	10.45–20.91	25 to 50	225–450	13.05–26.10
8	Universal joints	—	—	—	—	—	—	—	—	—
9	Clutch release	—	—	—	—	—	—	—	—	—
10	Rear springs	Graphite lubricant	—	Graphite	27.9	139.5	6.48	27.9	139.5	8.09
				Metal soap[7]	27.9	139.5	6.48	27.9	139.5	8.09
11	Parking brake cables	—	—	—	—	—	—	—	—	—
12	Water pump	Water pump grease	—	Metal soap[7]	—	50	2.32	—	50	2.90
13	Power steering mechanism	Power steering fluid	1.5 qt.	Detergent[1]	—	—	—	55.2	55.2[10]	3.20
				Sulfurized material	—	—	—	110.4	110.4[10]	6.40
				Inhibitor[2]	—	—	—	27.6	27.6[10]	1.60
				V.I. improver[3]	—	—	—	110.4	110.4[10]	6.40
	Body lubrication (door hinges, latches and strikers, all other small parts)	Light oil	32 drops	Oiliness agent[8]	0.2	1.7	0.08	0.2	1.7	0.10
				Antioxidant[2]	0.04	0.4	0.02	0.04	0.4	0.02
	Generator distributor	Heavy duty motor oil	Avg. of about ½ pt. per car(most for air cleaner)	Detergent[1]	11.1	44.5	2.07	11.1	44.5	2.58
				Inhibitor[2]	7.4	29.7	1.38	7.4	29.7	1.72
	Air cleaners starter fans			V.I. improver[3] and pour depressant[4]	6.9	27.8	1.30	6.9	27.8	1.61
				Antifoam agent[5]	Trace	Trace	Trace	Trace	Trace	Trace

[1] Such as sulfonates.
[2] Such as dithiophosphate.
[3] Such as polymers of esters of methacrylic acid.
[4] Such as wax-napthalene condensation products.
[5] Such as silicone polymers.
[6] Such as organic phosphate.
[7] Such as sodium stearate.
[8] Such as fatty alcohols.
[9] Such as petrochemical.
[10] Based on yearly change of fluid.

Assuming **all cars** had used the ethylene glycol type of anti-freeze solution, 859,510,000 lb of the material would have been consumed in the country's radiators as well as 27,880,000 lb of corrosion inhibitor.

Now as to the future:

In 1960 it is estimated that a projected census of 58,000,000 automobiles would use somewhere between 482,310,000 and 520,280,000 lb of additives in gasoline. The difference is due to the consumer's choice between additives of the types introduced to the market in the past two years. Texaco's additive, Petrox, is of the non-metallic, non-salt type. It is a wholly hydrocarbon-derived material.

In 1960 it is estimated that 393,040,000 lb of motor oil additives will be used, assuming that all cars will be using a fortified oil.

If all cars were to be equipped with automatic transmissions, the 1960

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census would consume 127,600,000 lb of additives in automatic transmission fluids. If 100 per cent of the cars were to be equipped with standard transmissions, 12,760,000 lb of additives would be used in the lubricant. Therefore, transmission additive consumption in 1960 will fall somewhere between the two foregoing figures.

In 1960 the chemicals required to supply **all** cars with ethylene glycol type anti-freeze would amount to 1,107,800,000 lb or to furnish **all** cars with methanol type anti-freeze, 813,-160,000 lb. No estimate is advanced here on the actual consumption of anti-freeze chemicals expected in 1960 nor on the portion of the market either type might assume.

It can be seen that the market in 1960 will be even greater than it is today. The accompanying table projects the entire use list through 1960.

The growth in use of chemical components in motoring products has been exceptional. What about the future? We can make one tentative generalization: While consumption will continue to grow, it is unlikely again to enjoy the rate of growth observed from 1941 through the present (discounting the impact of World War II). Future growth will be more closely linked to the gradual increase in the automobile census. Considerable volume growth of certain additives is indicated, however, in the accompanying table on the basis of potential 100 per cent application of such mechanisms as automatic transmission and power steering. For example, we show no consumption figures for the latter for 1953. If all cars in 1960 were to be equipped with this mechanism, additive consumption in power steering fluid would be 17,600,000 lb, a considerable increment in the growth picture. This potentiality reminds us that in looking forward we should keep in mind always the possibility of future technological changes in the automobile which will call for new or modified petroleum products containing chemical components.

Our prediction of continued growth is based on the assumption that the projected 1960 passenger car census refers to automobiles powered by gasoline piston engines.

In closing, a word of warning: It should be clearly understood that the chemical components shown in the accompanying table, and their volume according to type of product, are bound to vary greatly from one company to the other. The figures presented here represent a gross average for the industry and are **not** meant to represent the proportions any single company would employ in product formulation. ★ ★ ★

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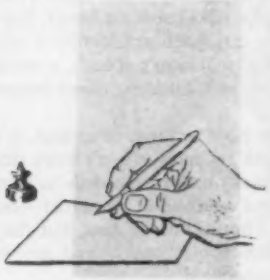


Communication:

democracy depends on democratic writing

Dennis Murphy

ALL communication through words is **verbal** whether it's spoken or written. About 90 per cent of all business is carried on by **oral** communication, but the other 10 per cent that's **written** is the part that counts. It's like the cream on the milk.

Business writing—memos, letters, and reports—is extremely important because it confirms our talks, verifies our research, and defines our transactions. Talking may dissolve into air, but writing stands as a permanent record.

Then why do engineers, lawyers, accountants, and geologists in the oil industry—indeed, most men in business generally—write with pompous words, involved sentences, and a dull heavy style? Bad writing is like being too fat: People grumble and complain about it but seldom try to remedy the trouble. They know something's wrong but don't always realize what it is.

This article tries to show exactly what it is, why it happens, and what we can do about it.

We've all read that the Gettysburg Address contains only 266 words and the Ten Commandments, 297; yet our government's OPA order to reduce the price of cabbage required 26,911 words. **This is no joke; it is a crime.**

Lincoln had little formal education, but he taught himself to write superbly well. That's why I say *you can train yourself* in all the communication skills—thinking, observing, writing, reading, talking, and listening—if you really want to.

Here's a Sample of Government Writing

"Unless the Office of Price Administration or an authorized representative thereof shall, by letter mailed to the applicant within 21 days from the date of filing application disapprove the maximum price as reported such price shall be deemed to have been approved, subject to nonretroactive written disapproval or adjustment at any later time by the Office of Price Administration."

We read this 60-word sentence half a dozen times but still can't understand it. What's the matter? Obviously, it's the writing or the reader. Sometimes we begin to doubt our own intelligence. Let's rewrite it:

"You must wait three weeks before you can charge the ceiling price you applied for. OPA can always change that price. If they do, they will write you a letter."

In three short sentences using 30 words we turn a hodgepodge into a readable communication. Two keys to easy understanding are:

(1) short sentences, and
(2) plain everyday language.

Here's One From the Oil Industry

"In emergencies, prepare Form 134 in the same manner as directed under A, above, and forward it to the SM&M Section on any workday; or, at locations outside the General Office, if the emergency necessitates shipments from the General Office on the same day as that on which the requisition is being made, telegraph or telephone (as appropriate) the requisitions of the location to the supervisor involved at the General Office, who will prepare Form 134 covering the telephone or telegraph request in the same manner as dircted under A, above, forwarding the last copy to the location originating the request, and all other copies, to the Comptroller, 'Attention: SM&M Section.'"

Here is a whole instruction letter in one sentence of 111 words. But as a communication it fails completely because nobody can understand it. Its repetitions are needless, and it emphasizes a process instead of the human beings involved.

The men who wrote this letter revised it themselves by using five short sentences, cutting out the deadwood, and talking *to* the reader:

"In emergencies, prepare Form 134 as shown in A above. Send it to the SM&M Section on any workday. For shipments on the same day, telegraph or telephone your request to the supervisor at the General Office. He will prepare Form 134 for your request. He will send you the last copy but send the Comptroller all other copies, marked 'Attention: SM&M Section.'"

Here's One From Business

A man from the field comes into the main office. His manager greets him warmly: "Why, hello, Jim. It's good to see you; how's everything out in Centralia? Heard you got married and think it's swell. Sit down and have a cigar, old man. You're goin' to lunch with me, too, after while."

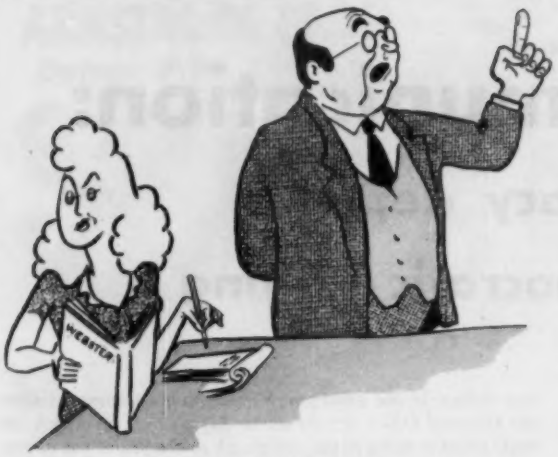
Ten days later the manager writes to Mr. James Smith:

Dear Sir:

Regarding the inquiry concerning Order F-407 of the 12th inst., please advise regarding approximate date of disposi-

Keep your words simple . . .

Editor's note: Dr. Murphy is administrative assistant, Service Pipe Line Company.



. . . simplicity of writing or wording . . .

tion of said material in accordance with instructions as per April 1, 1955.

Thus a warm-hearted manager becomes a cold and formal rubber-stamp, changes into a different person, the minute he starts a letter. Why should he turn into a stuffed shirt? Writing is a natural means of communication, like walking or talking. If only he would write simply and clearly!

What's Wrong Here?

These samples of communication in business, industry, and government are not exaggerations. They are typical. Our writing in the oil industry is shot through with stilted jargon of the worst kind. When it isn't flowery, it's ponderous. When it isn't filled with hackneyed trade terms, it's cluttered up with verbs in the passive voice or with a constant beating-around-the-bush with words.

Yet American business men have a practical down-to-earth approach to daily problems on their jobs. They desire, above all else, efficiency. In their work they cut through irrelevant details to arrive at workable decisions. In their common sense they are almost uncanny with analyses that lead to results.

But often when they write anything—memos, letters, or reports—they deviate, repeat, or effervesce. They get all balled up, fail to come to grips with their ideas, and seldom hit the nail on the head—much less clench it. It is ironical that men so progressive and productive can come up with writing so outmoded and wasteful.

They will ride in nothing but the latest streamlined cars, work with nothing but precision instruments and electronic machines of the best make, and live in nothing but modern homes with functional equipment of the newest model. Yet their daily writing is often a shambles, a shame, or a sham!

If a piece of machinery breaks down, they know immediately what to do. If their own communication breaks down, they are helpless.

How Did We Get That Way?

First. One reason for our poor writing is **tradition.** We inherited it from the nineteenth century when our ancestors (God rest them!) chose to say "exterminate the illumination" for "put out the light." A hundred years ago it was the custom to speak of "pedal extremities," "unmentionable social diseases," and "passed away into the Great Beyond."

The twentieth century, however, is one of scientific truth and accuracy. For better or for worse, our age has brought in a simplicity seen in our streamlined architecture, trains, automobiles, furniture, clothing, machinery—everything. It has brought in a writing, too, that is simple and functional. Why hasn't business writing kept pace?

Second. Another reason for bad writing is a *desire to impress* with showy language, especially when there's little to say. This pose works on a few who know no better, but most people aren't gullible. They can smell artificiality a mile off and detect it right away in a politician's speech, a minister's sermon, a professor's lecture, or a business man's letters and reports.

Third. A third reason for poor writing, of course, is *fuzzy thinking.* If a man can't think straight he can't write straight. He will use and misuse a great number of words as a smoke-screen. Then he confuses and confounds his reader—but not for long. Words can hide a multitude of sins; but they can never make up for the absence of thought, and any reader knows when he's being bamboozled.

Ghost Writing

Much of our business writing, too, is done for someone else. Or it is jointly done by many writers and cleared by many departments, where each author puts in his two cents' worth. Each one writes differently and wants every qualifying detail included exactly as he words it.

But too many cooks spoil the broth, and the net result is a hodgepodge that sounds like a lot of fuzzy thinking. The resultant mess is faulty communication, although each individual responsible for it is really a good thinker. No one has any pride of authorship, and no expert has simplified the final version.

Why do we overlook the importance of editing our work? We always plead that we don't have time to do this, but we should take time to read and edit each important piece of writing.

Why Our Writing Is Hard To Read

Some people believe a stricter adherence to correct grammar, spelling, and punctuation will achieve clear simple writing. This is a mistake. Good grammar, spelling, and punctuation are always necessary, but they are not the causes of unreadable writing.

The chief causes are:

1. *trite and pretentious words*
2. *long tangled-up sentences*
3. *useless repetitions*
4. *weak verbs in the passive voice*

"John *hit* the ball" uses the verb *hit* in the active voice; "The ball *was hit* by John" uses the same verb in the passive voice. Notice the difference?

Let's take a simple example. A sports writer reporting a baseball game writes: "Lemon struck out Williams and ended the game." This tells who did what. If we found this same statement in business writing it would probably read: "The contestation *was terminated* as a result of the fact that three strikes *were thrown* by the pitcher to the batter."

. . . keep your mind on what you are writing.

When you get an idea, write it down.

Twice too many words, and the stress is on an abstract game instead of on specific human beings, the players. It is awkward, indirect, and dull because it insists on passive verbs and avoids active ones. Nobody in business ever "does" anything; things "are done." Nobody ever "refers" to anything; but "reference is made" to everything!

The basis of better communication is to tell *who* does *what*, first of all, and then tell *why*, *where*, *when*, and *how*. Occasionally it isn't possible, or even advisable, to tell this much. But business writing in the past has been so obviously secretive that sometimes it has brought suspicion upon itself and even investigation from the outside. What on earth do we have to hide?

The Thinking Behind It

In the nineteenth century, apparently, the job was more important than the man who did it. The work was emphasized, but the worker was relegated to a secondary or subordinate place. And, as a result, we have all seen how men organize themselves for strength to gain this importance once denied.

Compare these sentences thoughtfully: (1) This work shall be done by this employee. (2) This employee shall do this work. (3) You shall do this work.

Sentence (1) glorifies a man's work by making it the subject, but subordinates man himself by making him a part of the phrase of agent.

Sentences (2) and (3) put a man on a level with his work. They make the laborer worthy of his hire by raising his position, elevating him, dignifying him. Is there any greater morale builder for men? These sentences also replace the weak passive verb "shall be done" with the active verb "shall do." Automatically they bring in the personal pronoun when they use the active voice.

Sentence (3), the shortest, is also the easiest to write and the easiest to understand. Instruction letters like it, for example, are as simple, clear, and direct as the recipes in a cookbook.

Remember Your Reader

The purpose of business writing is to communicate. No transfer of meaning can take place without readers. A good writer, then, always works with his readers in mind.

Know your audience. For example, if your letter is for a highly trained consultant, you may need technical and polysyllabic words. On the other hand, if your letter is for 8000 employees in a company, you cannot make it too simple.

Put yourself in the reader's place. Will he understand you in the way you want him to? What can you say to interest him? Are you giving him the *right* information and *all* that he needs? How can you persuade him to do the work you want done?

Write directly to him. Try to visualize the receiver of your communication. Make him feel that he's as good as you are, that he's not being talked down to. Remember, you're not writing to the wall or to space; you are always writing to somebody. That reader of yours is a human being, too.

And simple writing means not only that he can understand each sentence you write, but also that he cannot possibly misunderstand it.

Tips That Pay Off

1. *Organize your thoughts.*
2. *Use simple words.*
3. *Use short sentences.*
4. *Use brief paragraphs.*
5. *Use personal pronouns.*
6. *Use active verbs, not passive ones.*

Why Simple Writing Is Best

(1) **It makes communication more efficient.** Each of us becomes a more articulate citizen when we write in clear simple words. Long ago Euripides said, "The only slave is he who cannot express his thoughts." Trying to simplify our communication, we come to closer grips with our ideas and become clearer thinkers. In doing this, we save our readers many doubts and much confusion.

(2) **It saves the company both time and money.** And time is money. This is an important material view to take. Let's illustrate.

Suppose it takes a staff writer 3 hard-spent hours to rewrite an instruction letter that goes out to 1000 employees. Suppose it saves each of them only 5 min to read it and understand it correctly. This letter, then, saves 5000 min or over 83 man-hours for the company.

Thus it has cost 3 hr in the main office to save 83 hr among all the workers. Figure that out in actual dollars and cents saved on thousands of pieces of writing each year, and we see why progressive firms are beginning to hire writing advisers and consultants.

(3) **It promotes better human and industrial relations.** After all, every company is made up of men and women working together toward a common goal. Any firm's greatest achievement depends upon every worker's doing a useful and needed task smoothly.

In our writing we must always consider our reader, the other fellow, whether he is the humblest or the highest. We can't look down our noses and write like snobs. We can't lord it over and write like dictators. We can't bellow out a lot of words and write like fools or windbags.

Clear simple writing is democratic writing because it's the only kind that everybody can understand. Business writing must reach everybody. As the NEW YORK NEWS used to instruct its reporters, "Tell it to the Sweeneys and the Stuyvesants will understand, but tell it to the Stuyvesants and the Sweeneys may *never* understand."

Simple writing helps to eliminate differences, controversies, and misunderstandings that arise from communication that is confusing. Many conflicts and disputes, even strikes and wars, often arise from messages that are obscure or misleading.

Simple writing, of course, can never solve all of our ills. But it is a fine lubricant for the intricate machinery of business and will help to keep it running smoothly and efficiently. **So let's simplify our writing.** ★ ★ ★

World Refining Capacity Nears 18 Million Barrels Crude Oil Daily

Ernestine Adams

WHEN plant construction in 1956 is complete world-wide refining crude capacity will be more than 18,000,000 bbl a day. In the meantime, of course, older units will be shut-down and construction of new plants will begin.

Refining capacity in 66 countries of the world, which have one or more plants, is presently 16,971,560 bbl a day, more or less, depending on what new units have gone on stream since the table was compiled. This includes an estimated 1,440,650 bbl a day for Communist countries, where actual data are not available.

There are at this time some 734 refineries in the world, including those that may be closed down for one reason or another. Of these, the number in Communist countries is estimated at 96 plants.

Roughly, some 14,400,000 bbl a day of crude oil are refined into products — principally gasoline. This is 2,500,000 bbl a day below capacity. In Iran, for instance, the Abadan plant had a pre-nationalization capacity of 500,000 bbl a day. The Iranian Oil Participants in November had 141,000 bbl a day refinery runs.

The figures in the table have been checked by government officials in most instances and by companies that have plants under construction. They should be fairly accurate. The time is not always consistent; most of the data concern the last half of 1955.

The wide discrepancy between crude capacity of plants in the free world and in the Communist countries is striking. Of course, figures for the latter are only estimates but they are pretty well agreed upon by authoritative economists in the United States and Great Britain. If they are close to the mark, free world refineries have 11 times the crude oil capacity to be found in plants in the Soviet and its satellites.

REFINING DATA IN COUNTRIES AROUND THE WORLD

Country	No. ref.	Total capacity	Avg. runs bbl/day	Average output bbl/day: Gasoline	Kerosine	Dis. & res. fuel oil	Plants under construction: Company	Location	Type	Bbl/day capacity
WORLD TOTAL	**734**	**16,971,560**	**14,429,900**	—	—	—	—	—	—	**1,814,652**
Aden	1	100,000	85,000	—	—	—	—	—	—	—
Argentina	17	195,000	160,000	40,000	18,000	87,700	Diadema (Shell)	Buenos Aires	lube	500[2]
							Jersey-Campana		lube	1,000
Australia	5	196,900	106,726	24,664	600	25,500	Standard-Vacuum	Altona	alkylation	1,600
							Australasian Oil Ref.	Kurnell	skim & crack	22,000[2]
							Bitumen & Oil Ref.	Matraville	crude unit	9,000
Austria	7	53,000	30,000	—	—	—	None	—	—	—
Bahrain	1	186,500	210,000	47,600	21,700	116,200	Bahrain Pet. (Caltex)	Bahrain	cat reformer	10,000
									vacuum	23,000
Barbados (W.I.)	1	240	240	—	—	—	None	—	—	—
Belgium	7	112,100	80,000	—	—	—	None	—	—	—
Bolivia	4	12,300	6,950	2,950	450	3,250	YPF	Cochabamba	lube	162
Borneo British	1	47,400	45,000	—	—	—	None	—	—	—
Brazil	8	91,800	17,000	2,300	330	3,300	Petrolras	Mataripe	lube parafin	32,300
							Petrolras	A. Bernardes	topping	20,000
Burma	1	2,900	2,900	—	—	—	Burma Oil Co.	Rangoon	distillation	4,000
Canada	43	560,000	487,000	207,400	23,300	205,000	Husky	Fort Williams	diesel fuel	1,000[2]
							British American	Montreal	cat reformer	13,000
							Canadian Petrofina	Montreal	gas oil	3,000[2]
							Shell of Canada	Montreal	gas oil	7,500
							Imperial	Montreal	vacuum	41,400
									distillation	11,100
							North Star Oil	St. Boniface	complete	12,000
							Husky	Moose Jaw	catformer	1,000
									vacuum unit	4,500
									hydro desul.	1,000
							Imperial	Ioco	cat. poly.	—
							X-L Refineries	Dawson Creek	complete	2,000
							McColl-Frontenac	Montreal	cat ref. feedstocks	12,000[2]
Chile	2	20,700	14,000	9,900	1,000	7,400	None	—	—	—
Colombia	4	44,650	39,000	12,400	2,250	20,000	Intercol	Cartagena	topping, poly, cat crack	28,000
Cuba	6	10,100	9,600	2,800	1,900	3,850	Shell of Cuba	Havana	complete	25,000
							Esso	Belot at Havana	—	25,000
							Texas Co.	Santiago de Cuba	—	20,000
Denmark	3	1,000	900	—	—	—	—	—	—	—
Ecuador	2	6,050	4,800	2,000	600	2,100	None	—	—	—
Egypt	2	66,000	51,000	5,200	5,300	36,000	Government	Suez	—	17,000
							Government	Cairo	—	46,000
Finland	0	—	—	—	—	—	Government	Tupavuori	—	18,000
Formosa	2	18,400	8,000	—	—	—	Chinese Pet. Corp.	Kaohsiung	cat cracker	6,500[2]
France	15	610,000	530,000	125,800	11,500	297,000	Pechelbron SA	Strasbourg Port	—	12,000
							Francaise deRaffinage	La Mede	distillation	—
							Francaise deRaffinage	Gonfreville	cat cracker	—
							Shell-Berre	Petit-Couronne	cat cracker	13,000
							Raf. de Petrole de la Gironde	Ambes	cat cracker	4,600
									vacuum	6,300
									poly.	540
							Socony-Vacuum	Gravenchon	sovaformer	4,100
							Esso Standard	Port Jerome	poly. former	—
							Antar-Petroles de l' Atlantique	Donges	houdriformer	10,800

Continued — REFINING DATA IN COUNTRIES AROUND THE WORLD

Country	No. ref.	Total capacity	Avg. runs bbl/day	Average output bbl/day, Gasoline	Kerosine	Dis. & res fuel oil	Plants under construction: Company	Location	Type	Bbl/day capacity
Germany Western	25	272,300	250,000	84,000	3,400	120,000	British Petroleum	Hbg-Finkenwerder	hydrofiner	6,000
							Esso AG	—	dis., cat cracker	65,000
							Esso AG	Hamburg-Harburg	hydrofiner	8,000
							Gew. Deurag-Nerag	Misburg/Hanover	platformer	2,500
							Gew. Erdoel-Raf. Em.	Lingen on Ems.	cat reformer	3,000
							Mawag	Ostermoor	distillation	2,100
							Deutsche,Shell AG.	Hamburg-Harburg	dis. cat cracker, etc.	36,500
							Ruhrchemie AG	Oberhausen	cat cracker	5,600
Greece	—	—	—	—	—	—	Government	Aspropurgos	distil. & cat.cracker	26,000
Hawaiian Islands	1	3,000	3,000	—	—	—	—	—	—	—
India	3	73,600	73,600	—	—	—	Caltex (India)	Visakhapatnam	comp.	13,500
Indonesia	5	220,000	263,000	60,600	29,500	148,233	Standard-Vacuum	Sumatra	FCC	10,000
								Sumatra	cat. poly	1,100
Iran	2	580,000[1]	154,000	—	—	—	None	—	—	—
Iraq	5	42,700	19,000	—	—	—	None	—	—	—
Israel	1	85,000	21,000	—	—	—	None	—	—	—
Italy	38	450,000	340,000	63,400	15,000	133,600	Garrone	Genoa	cat reformer	4,800
									cat reformer	3,600
							IROM	Marghera, Venice	platformer	2,000
							Purfina	Milan	vacuum distil.	3,000
							Socony-Vacuum	Naples	cat cracker	22,000
							STANIC	Leghorn	fluid hydro.	6,000
							AGIP	Caligi	comp.	—
Japan	18	150,000	146,500	37,000	9,700	83,633	Nippon Pet. Ref. Co.	Yokohama	topping	20,000
								Kudamatsu	crude unit	15,000
							Koa Oil Co.	Marifu	topping	15,000
							Mitsubishi Oil Co.	Kawasaki	—	7,600
Kuwait	1	30,000	29,000	5,800	2,800	19,500	Kuwait	Persian Gulf	bitumen	600
Lebanon	2	20,600	—	—	—	—	None	—	—	—
Mexico	8	330,000	236,000	40,200	12,400	152,760	Pemex	Guaymas	—	1,500
							Pemex	Mexico City	—	1,900
							Pemex	Minatitlan	—	1,150
							Pemex	Ciudad Madero	cat & fl. coker	22,000
Morocco French	1	3,000	2,400	1,000	265	1,600	SCP	Petitjean	topping	3,500
Netherlands	2	230,000	233,000	63,100	13,970	161,560	Caltex	Pernis	diesel desul	4,000
							Shell	Pernis	cat cracker	33,000
Netherlands Antilles	2	631,000	400,000	—	—	—	CPIM (Shell)	Curacao	cat cracker	35,000
Norway	1	1,800	—	—	—	—	None	—	—	—
Pakistan	1	5,400	5,400	—	—	—	None	—	—	—
Peru	3	47,200	39,914	12,991	6,208	19,861	None	—	—	—
Philippines	1	13,000	12,000	5,100	1,000	4,800	—	—	—	—
Portugal	1	25,000	15,500	—	—	—	—	—	—	—
Puerto Rico	1	10,500	13,000	—	—	—	Commonwealth Oil	Guayanilla Bay	Complete	23,500
Qatar	1	300	200	—	—	—	—	—	—	—
Saudi Arabia	1	189,000	218,000	35,500	23,400	146,900	Aramco	Saudi Arabia	cat desul.	15,000
Sicily	2	45,100	—	—	—	—	ISLOM	Gaeta	comp.	—
							RASIOM	Augusta	ultraformer	5,000
South Africa	1	15,600	16,000	—	—	—	—	—	—	—
Spain	3	80,500	74,000	11,900	2,900	40,700	CEPSA	Canary Islands	distillation	10,000
							Calvo Sotelo	Puerto Llano	comp.	15,000
							REPESA	Escombreras	topping	35,000
									platformer	8,000
Sweden	3	41,000	34,000	—	—	—	—	—	—	—
Switzerland	2	2,000	—	—	—	—	—	—	—	—
Trieste	3	23,000	—	—	—	—	—	—	—	—
Trinidad	3	120,000	—	—	—	—	—	—	—	—
Turkey	1	300	200	—	—	—	Ortaklik	Batman	cat cracker	6,600[2]
United Kingdom	15	585,000	576,600	144,500	13,560	341,600	Kent Oil	Isle of Grain	hydrofiner	8,000
							Esso	Fawley	vacuum still	27,000
									hydroformer	15,000
							Vacuum Oil Co.	Coryton	alkylation	—
							Shell	Shell Haven	cat reformer	6,700
United States	341	8,302,000	7,583,000	830,000	63,000	623,300	(Too many to list here)			700,000
Uruguay	1	27,000	24,268	5,276	3,197	15,393	(Studying expansion)	—	—	—
Venezuela	14	523,970	491,000	69,370	15,767	393,300	Shell de Venezuela	Cardon	cat cracker	35,000
Yugoslovia	3	17,000	15,000	2,400	1,200	—	Government	—	—	4,000
COMMUNIST COUNTRIES (all estimates)										
Albania	3	6,000	5,500	—	—	—	—	—	—	—
Bulgaria	3	2,250	2,400	—	—	—	Government	Varna	—	50,000
China	8	10,000	—	—	—	—	—	—	—	—
Czechoslovakia	7	34,000	—	—	—	—	—	—	—	—
Germany, East	6	30,000	30,000	—	—	—	—	—	—	—
Hungary	8	40,000	—	—	—	—	—	—	—	—
Poland	6	8,400	—	—	—	—	—	—	—	—
Romania	15	160,000	40,000	—	—	—	—	—	—	—
U.S.S.R.	40	1,150,000	1,130,000	—	—	—	—	—	—	—
TOTAL COMMUNIST	**96**	**1,440,650**	**1,300,300**							

[1] The figure of 500,000 B/D included for Abadan refinery is pre-nationalization capacity. [2] Went on stream during 1955.

SEVEN CAT* OILFIELD ENGINES POWER DIXIE'S NEW OFFSHORE RIG

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And there has been a continual parade of engine and electric set improvements coming from Caterpillar. For instance, the new D337 (Series F) has been turbocharged to produce 310 HP maximum at 2000 RPM. All Cat Engines are offered with a choice of three starting systems—air, electric and gasoline. And there are many other recent advances in this and other Caterpillar Oilfield Engines.

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P 941.c

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Don't Overpay Your Taxes

WHETHER the federal income tax rates are cut or not, you may be able to cut your own tax bill — honestly!

To do this you need to know the tax effect of various choices. Your choice of a method of handling a particular transaction can raise or lower your taxes, and sometimes you can save money by a legitimate shift of taxable income or deductions from one year to another. You are also allowed choices in your treatment of certain items in your tax return, such as depreciation and research costs.

Many businesses could reduce their tax burden if they were aware of the tax considerations affecting a variety of transactions. If the firm retains a certified public accountant or a firm of CPAs, there should be tax consultations not just once a year when the filing date approaches, but throughout the year as decisions are made which will affect the tax.

Choice of Depreciation Method

Certain tax-saving steps are still possible at tax-filing time. One of them is the proper choice of depreciation method. The first step is to determine the estimated useful life of any asset acquired during the tax year. Every businessman should have a copy of "Bulletin F," which contains tables of "average" useful lives. It is available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., for 30 cents. The tables provide a guide, but it is not necessary to follow them exactly.

The simplest method is straight-line depreciation. It may also be the best in your particular case. Just divide the cost (less what you expect to sell it or trade it in for when it is replaced) by the number of years of estimated useful life, and this is the amount to be deducted each year. In arriving at the original cost, don't forget to include freight and installation charges in addition to the price paid for the equipment.

The law now specifically permits several other methods of depreciation for new assets having a useful life of three years or more. One of them is known as the declining balance method. In the first year the depreciation rate is twice what it should be under the straight-line method. The next year the same rate is applied to the amount remaining to be depreciated. This process is repeated each year.

The result is that a greater proportion of the cost is depreciated during the early years of the life of the asset.

Another new method, known as "sum of the years' digits," has a similar effect. You should figure depreciation on a new asset in all possible ways so that you can decide which is best for you and make the proper choice.

These methods of rapid depreciation may be particularly helpful to a company which is currently making large outlays for new equipment, but the depreciation left for the later years of the asset's life will be less than under the straight-line method. The best method depends upon the circumstances of the individual company, and is also affected by such imponderables as estimates of future earnings and tax rates during the life of the asset.

Research and Development

Another choice confronting the taxpayer is whether to treat research and development costs as immediately deductible expenses or to amortize them over a period of years. The immediate deduction is certainly a "bird in the hand" and may be very attractive to a company which needs this tax benefit to help finance the undertaking.

The company which can afford to spread the cost over the estimated useful life (or at least sixty months if the useful life cannot be determined) may find it best to do so. This is especially likely to be advantageous for companies whose income is expected to increase.

Being Taxed As a Corporation

There is a provision in the 1954 Internal Revenue Code which allows some proprietorships and partnerships to be taxed as if they were corporations. This choice should not be made lightly, as there is considerable uncertainty about the provision and the proprietorship or partnership desiring corporate tax treatment might find it better actually to incorporate.

Choice of Fiscal Year

Regulations now permit changes of fiscal year in some cases without permission of the Treasury Department. Generally it is wise to use the fiscal year which corresponds most nearly with the annual cycle of business operations, ending at the low point of receivables, inventories and loans, instead of a calendar year. This reduces the area of possible dispute over such matters as value of inventories, and has many advantages apart from tax considerations. The change should be carefully timed, though, to avoid possible adverse tax effects during the changeover period.

Sickness and Accident Benefits

Under the present tax law, payments from your company to employees for treatment of sickness or injury are not taxed as income of the employees. If the company has a plan for continuing all or part of an employee's pay while he is absent for sickness or injury, limited amounts of this "sick pay" are also tax exempt.

This applies whether the payments are made by the company or by an insurance company. In the case of a sickness requiring hospitalization even for one day during the course of the illness, or in the case of **any** injury, the first $100 per week of payments are tax free. In the case of sickness which does not require as much as a day's

Editor's Note: This information has been supplied by the American Institute of Accountants.

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hospitalization, the exemption begins after the first week of absence.

No great formality is required concerning the "plan" but it should be explained to employees, and appropriate records kept of the amounts paid. Proposed regulations governing tax withholding in 1956 from payments to ill employees were still under discussion when this article was prepared.

Repairs and Improvements

If you contract for repairs and improvements to your business property, be sure that these two types of work are billed separately. Should you lump them together, you may find that the entire cost has to be capitalized for future depreciation. By listing the cost of repairs as a separate item you are allowed to deduct it as an expense of the current year.

For example, you might have a furnace repaired and new radiators added. By separating the charges you can deduct the cost of the repairs in the current year, although the new radiators would be improvements subject to depreciation during their useful life.

Keeping Good Records

Many deductions are lost through failure to keep adequate business records. Be sure that you have good records to show you what deductible expenses you have had, and to back up your deductions in case they are questioned by the Government. This applies particularly to your out-of-pocket business expenses, such as travel and entertainment of customers, and to items which are deductible on your personal income tax return.

Good records and properly qualified professional tax assistance — at tax-filing time and throughout the year — are the keys to income tax savings. ★

First-Year Rents Under Government Oil Leases

The Tax Court and Tenth Circuit Court of Appeals have already held that the first-year rental payments on noncompetitive oil and gas leases from the government are currently deductible business or nonbusiness expenses. They rejected the Commissioner's argument that the payments were capital expenditures recoverable only through depletion deductions.

The Ninth Circuit has just lined up with the Tax Court and Tenth Circuit in allowing the current deduction. (Com. v. Robert H. Miller *et ux.*, (CA-9) 11/17/55).

Observation: This means that even though the Treasury continues to fight the deduction, taxpayers can be sure of appealing successfully in the following states: Arizona, California, Colorado, Idaho, Kansas, Montana, Nevada, New Mexico, Oklahoma, Oregon, Utah, Washington, and Wyoming.

Taxation Report.

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Meetings

Jan. 16-18—**Pipe Line Contractors Association,** Boca Raton, Florida.

Jan. 19—**New England Gas Association,** operating division, Hotel Statler, Boston, Massachusetts.

Jan. 20—**Southern Gas Association** employee relations conference, Shamrock Hotel, Houston, Texas.

Jan. 26-27—**Fifth Annual Instrument Short Course,** sponsored by Southern California Meter Association and Los Angeles Harbor Junior College, Los Angeles Harbor Junior College, Wilmington, California.

Jan. 27—**Southern Gas Association** accident prevention conference, Jung Hotel, New Orleans, Louisiana.

Jan. 30-Feb. 3—**American Institute of Electrical Engineers,** Winter general, Statler Hotel, New York, New York.

Feb. 15-17—**National Association of Corrosion Engineers,** Corrosion short course for Pipeliners, Mayo Hotel, Tulsa, Oklahoma.

Feb. 19-23—**American Institute of Mining and Metallurgical Engineers,** annual, Statler Hotel, New York, New York.

Feb. 24—**Natural Gasoline Association of America,** Permian Basin regional, Lincoln Hotel, Odessa, Texas.

Feb. 26-29—**American Institute of Chemical Engineers,** Statler Hotel, Los Angeles, California.

Feb. 27-29—**American Association of Petroleum Geologists,** Rocky Mountain division, Auditorium, Denver, Colorado.

Feb. 27-March 2—**American Society for Testing Materials,** committee week, Hotel Statler, Buffalo, New York.

March 7-9—**American Petroleum Institute,** Division of Production, Southern district, Plaza Hotel, San Antonio, Texas.

March 12-16—**National Association of Corrosion Engineers,** annual, Statler Hotel, New York, New York.

March 19-21—**Mid-West Gas Association,** Hotel Fontenelle, Omaha, Nebraska.

March 19-20-21—**Western Petroleum Refiners Association,** annual, Plaza Hotel, San Antonio, Texas.

March 21-23—**American Petroleum Institute,** Division of Production, Southwestern district, Texas Hotel, Fort Worth, Texas.

March 21-23—**American Power Conference,** annual, sponsored by Illinois Institute of Technology, Hotel Sherman, Chicago, Illinois.

March 22-23—**New England Gas Association,** annual meeting, Statler Hotel, Boston, Massachusetts.

April 2-4—**American Institute of Electrical Engineers,** Southwest district No. 7, Dallas, Texas.

April 3-5—**Annual Corrosion Control Short Course,** University of Oklahoma Extension Study Center, Norman, Oklahoma.

April 4-6—**American Gas Association,** General Management Section, spring conference, Conrad Hilton Hotel, Chicago, Illinois.

April 4-6—**American Petroleum Institute,** Division of Production, Mid-Continent district, Broadview Hotel, Wichita, Kansas.

April 9-10—**Ninth Oil Recovery Conference,** a symposium on "Natural Gas in Texas," sponsored by Texas Petroleum Research Committee, Texas Memorial Student Center, Texas A&M College, College Station, Texas.

April 11-13—**Natural Gasoline Association of America,** annual, Texas Hotel, Fort Worth, Texas.

April 14-19—**Petroleum Equipment Suppliers Association,** Boca Raton, Florida.

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April 15-17—**Texas Independent Producers and Royalty Owners Association,** Statler Hilton Hotel, Dallas, Texas.

April 18-20—**National Petroleum Association,** semiannual meeting, Cleveland Hotel, Cleveland, Ohio.

April 18-20—**American Petroleum Institute,** Division of Production, Rocky Mountain district, Cosmopolitan Hotel, Denver, Colorado.

April 19-21—**Indiana Gas Association,** French Lick Springs Hotel, French Lick, Indiana.

April 23-25—**Southern Gas Association** convention, annual, Statler Hilton Hotel, Dallas, Texas.

April 23-26—**American Association of Petroleum Geologists, Society of Economic Paleontologists and Mineralogists,** annual meeting, Conrad Hilton Hotel, Chicago, Illinois.

April 25-27—**American Petroleum Institute,** Division of Production, Eastern district, Statler Hotel, Deshler-Hilton Hotel, Columbus, Ohio.

April 25-29—**World-Oil Exposition,** Houston, Texas.

April 26-27—**American Institute of Electrical Engineers,** national meeting, Bradford Hotel, Boston, Massachusetts.

May 1-3—**Petroleum Industry Electrical Association and Electrical Suppliers Association,** annual conference and exhibits, Statler Hilton Hotel, Dallas, Texas.

May 6-9—**Liquefied Petroleum Gas Association,** convention and show, Conrad Hilton Hotel, Chicago, Illinois.

May 6-9—**American Institute of Chemical Engineers,** Roosevelt Hotel, New Orleans, Louisiana.

May 10-11—**American Gas Association** gas supply, transmission and storage conference, Conrad Hilton Hotel, Chicago, Illinois.

May 10-11—**American Petroleum Institute,** Division of Production, Pacific Coast district, Statler Hotel, Los Angeles, California.

May 14-16—**American Petroleum Institute,** Pipe Line conference, Shamrock Hotel, Houston, Texas.

May 14-16—**Petroleum Electric Power Association,** 27th annual meeting, Driscoll Hotel, Corpus Christi, Texas.

May 14-17—**American Petroleum Institute,** Division of Refining, midyear meeting, Montreal, Canada.

May 22-24—**Pennsylvania Gas Association,** Pocono Manor Inn, Pocono Manor, Pennsylvania.

May 24-25—**Natural Gas and Petroleum Association of Canada,** Sheraton Brock Hotel, Niagara Falls, Ontario, Canada.

June 17-22—**American Society for Testing Materials,** Pacific Coast meeting, Hotel Statler, Los Angeles, California.

June 26-29—**Canadian Gas Association,** Manoir Richelieu, Murray Bay, Quebec, Canada.

Sept. 9-12—**American Institute of Chemical Engineers,** William Penn Hotel, Pittsburgh, Pennsylvania.

Sept. 10-14—**International Congress on Catalysts,** Bellevue-Stratford Hotel, Philadelphia, Pennsylvania.

Sept. 11-13—**Pacific Coast Gas Association,** annual meeting, Coronado, California.

Sept. 12-14—**Third Annual Electrical Conference of the Petroleum Industry,** sponsored by American Institute of Electrical Engineers and Kansas City Section of AIEE, Kansas City, Missouri.

Sept. 16-22—**American Society for Testing Materials,** Pacific Coast meeting, Hotel Statler, Los Angeles, California.

Oct. 1-5—**American Institute of Electrical Engineers,** Morrison Hotel, Chicago, Illinois.

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When the new units are placed on the line, the enlarged station will handle 24 mmcfd. Residue gas from the main plant will be picked up at 2000 psig and boosted to 4000 psig for injection into the reservoirs. As field operating conditions change, CVOC personnel will install new outer head plugs furnished with the units. The station will then be capable of compressing 29 mmcfd from 2500 psig to 4500 psig.

This on-the-job modification to the compressors will permit the production of the reservoirs to their final stages without compressor cylinder change. No additional operating personnel will be required as the units have been equipped with automatic controls that permit their unattended operation except for scheduled maintenance. Highly salvable, the entire installation can be moved to other service when the Justiss Reservoirs are depleted.

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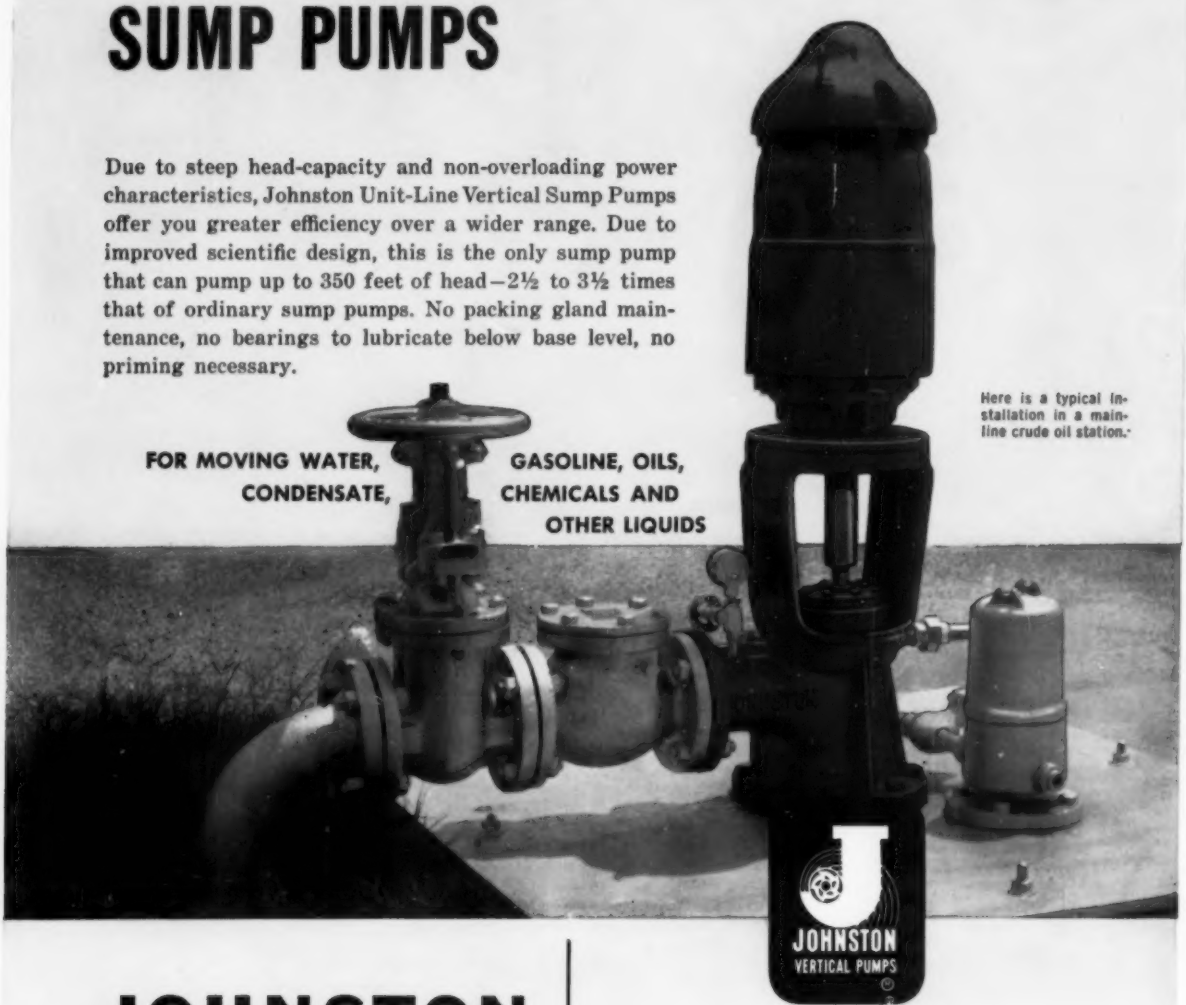

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PERSONALS

Charles R. Brown, vice president of Tide Water Associated Oil Company, has been named assistant general manager of the company's central division with headquarters at Tulsa, Oklahoma. Brown

C. R. Brown

T. M. Dailey, Jr.

moves to Tulsa from his present post as assistant general manager of Tide Water's western division. Brown has been associated with Tide Water since 1917. Elected vice president in 1948, he became assistant general manager of the company's West Coast operations last year. **Thomas M. Dailey Jr.** has joined Tide Water as manager of the economics department. For the past nine years, Dailey has been petroleum economist for Humble Oil and Refining Company, Houston, Texas. From 1936 to 1946, he was associated with Woodley Petroleum Company, also in Houston. Dailey attended the University of Texas.

Nicholas J. Campbell Jr. has been elected a vice president of Creole Petroleum Corporation. Campbell is presently manager of the law department, with headquarters in Caracas, Venezuela. He will assume his new title and duties early this year, at which time he will move to the New York City office. Campbell began his services with Creole Petroleum in 1947 as an attorney in the New York office. He was made manager of the law department in 1953. Campbell is a graduate of St. Vincent College and Harvard Law School.

George J. O'Brien has been placed in charge of the conservation activities and relationships with government agencies for Standard Oil Company of California. O'Brien, a vice president, has been general representative for the company in Southern California for the last 14 years. He recently was elected president of the Huntington Beach Company, which position will require frequent visits to Southern California in the future.

Cecil Morgan, government relations counselor for Standard Oil Company (New Jersey) since 1952, and a former vice president and director of Esso Standard Oil Company, has been appointed executive assistant to Jersey Standard's chairman of the board, Eugene Holman. Associated with the Jersey organization since 1936, when he joined Esso Standard's legal staff at Shreveport, Louisiana, Morgan succeeds **George Koeeler,** who became Jersey's deputy general counsel in November. He became a vice president of Esso Standard at Baton Rouge, Louisiana, in 1949. Morgan was educated at Louisiana State University, from which he received his law degree.

Don W. Woods, director and general counsel of General Petroleum Corporation, has ended an active career in the West Coast petroleum industry, which covered a span of nearly 40 years. His official retirement date from General Petroleum is next April 1.

Frank D. Lortscher has been elected to the board of directors of the Signal Oil and Gas Company. Lortscher presently holds the position of manager of purchases and stores of Signal and has served that organization a total of 28 years in various capacities. He served as president of the Los Angeles Purchasing Agents Association during 1952-1953 and has also served a term as national chairman of the oil buyers group of the National Association of Purchasing Agents.

E. A. Williford, Continental Oil Company sales executive, is the new chairman of the Texas Oil Industry Information Committee. Williford also became a member of the six-state executive committee at a December district meeting in Birmingham, Alabama.

John P. Herrick, oil man and author of Los Angeles, California, has increased from three to seven the number of perpetual scholarships he has endowed at The Pennsylvania State University in memory of Edwin L. Drake, who drilled the world's first commercial oil well at Titusville, Pennsylvania, in 1859.

The six scholarship winners chosen thus far are: **David Garrett Towell,** Fillmore, New York; **James T. Corless,** West New York, New Jersey; **Charles Bowman,** Pittsburgh, Pennsylvania; **Earl Hoyt,** Lansdowne, Pennsylvania; **Forrest M. Sittig,** Bradford, Pennsylvania, and **J. F. Lander,** Clearfield, Pennsylvania.

George R. Ferguson has been appointed general manager of the newly formed North European division of California Texas Oil Company, Ltd. He was formerly

G. R. Ferguson

W. E. Murray

general manager of the Caltex Far East division. Ferguson, who has been with Caltex since it was formed in 1936, will be replaced in his former position by **William E. Murray,** who has many years of experience with Caltex in the Orient. **William Schwarz,** formerly Caltex shareholders representative in Italy, has been appointed general manager of the new South European division. **S. H. Kuhn,** who has been with Caltex and predecessor companies for 35 years, has been named general manager of the Australasian division. **Thomas W. Donlon** has been appointed general manager of the producing division of the company.

The following appointments in Caltex affiliated companies have been announced: **Arthur B. Lawrence Jr.** has been appointed a director of Caltex Trading and Transport Company, Ltd., and managing director of its trading division. Lawrence has also become a director and managing director of Caltex (U. K.) Ltd., and Caltex Lubricants, Ltd. These companies have their principal offices in London, England. He fills vacancies in these positions created by the resignation of **Starley F. M. Alford,** who will remain in London to devote full time to financial liaison duties. **Per A. G. Kylberg** has been elected general manager of Caltex Oil A. B., in in Sweden.

William N. Bonner Jr. has resigned as secretary and general counsel of Texas Gas Corporation and its subsidiary companies. Bonner has not disclosed his future plans, and no successor to him has been named.

James T. Wood Jr. has been named vice president for The Texas Company at Los Angeles, California, and **Harris T. Dodge** and **Frank M. Dawson** have also been elected vice presidents. Wood, who has been vice president in charge of foreign operations (Western Hemisphere and West Africa) since 1950, will succeed **T. H. Webb,** who is retiring on

J. T. Wood, Jr.

F. M. Dawson

H. T. Dodge

January 1, after 33 years of service with the company. Dodge, general manager of foreign operations (Western Hemisphere and West Africa) since 1954, will succeed Wood as vice president in charge of the department. Dawson, who has been manager of the company's purchasing department, has become vice president in charge of the supply and distribution department.

Arch W. Baucum has been appointed general manager of the foreign operations (Western Hemisphere and West Africa) department and **Howard S. McCray** manager of the purchasing department. Baucum has been assistant to the president since 1954. He formerly was assistant to the vice president in charge of the domestic producing department. Baucum joined The Texas Company in 1934, after being graduated from Texas A&M College. McCray was operations manager for the refining department. He went to work for The Texas Company in 1926 after being graduated from Pennsylvania State College.

John D. Horrall has joined the public relations staff of General Petroleum Corporation. He was former news editor of the San Francisco Call-Bulletin.

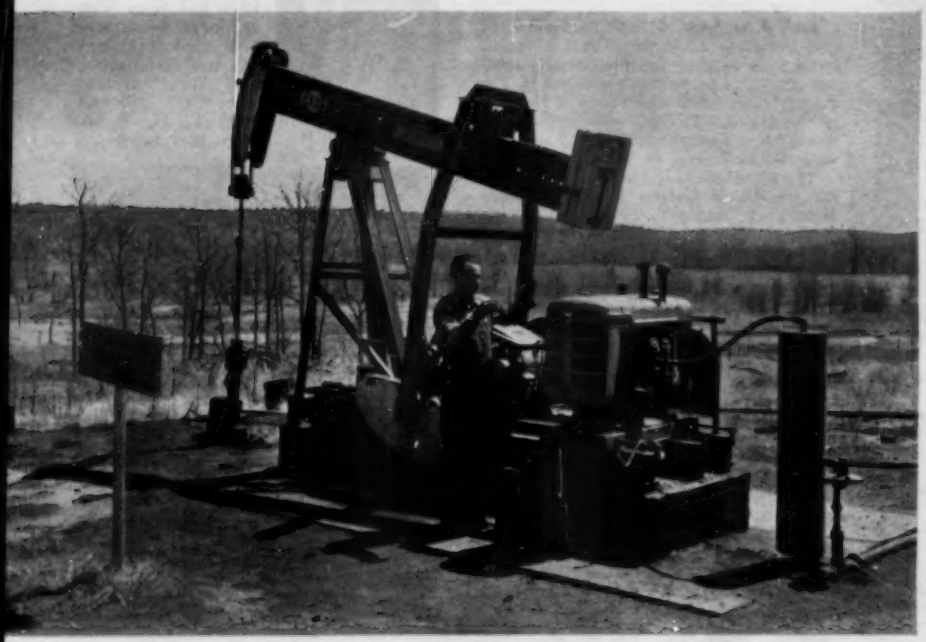
Elmer H. Wellemeyer, has been elected vice president of Cities Service Petroleum, Inc., which is the top petroleum advisory group of Cities Service Company.

A PICTURE REPORT OF

INTERNATIONAL POWER *in action!*

Boosting job production everywhere

6 years, no overhauls—TD-14 with Superior Pipe-Boom, rear right, was bought by Luther Harper, Turley, Oklahoma pipe-layer, in 1949. In 10,000 hours since then, it has needed no major overhauls. TD-14, with Superior Boom, foreground, newest of Harper's 6 International crawlers, was bought for this job—laying 3½ miles of 12 inch gas line in East Tulsa. Last year, Mr. Harper's 6-unit IH fleet put in or removed 160 miles of pipe, some 24 inches in diameter.



120 IH engines for L. B. Johnson, used by this Kiefer (Okla.) company on wells near Tulsa. Here, Master Mechanic Joe Vanardel inspects a 24 hp U-2A which pumps a 1700-ft. well. "International engines are easy to work on and low in maintenance cost," he says. "Some of our units haven't needed any work in 4 years. Others, on continuous hard-pumping wells, easily run a year, 24 hours a day, between overhauls."

Contract-drilling in Louisiana, Lloyd & Langston report the 83 hp butane-burning International engine which powers their drill rig "has needed no repairs in 2 years of use." Rig is shown drilling 3500-ft. well at Hosston.

Digs oil reserve pit—That's just one of many tasks Dick Sieber Excavating Co., Pauls Valley, Oklahoma, assigns their 4 TD-14's. "New TD-14's provide solid comfort," says Operator Lloyd Nelson. "I can really relax in the big, soft seat. Operation is simpler, too. Controls are handy—right where I can reach them naturally. And I'm sure going to appreciate the open deck on those hot days next summer!"

Personals

Col. T. H. Barton, former chairman of the board of Lion Oil Company, which

Overseas Oil Company have all been chosen from senior members of the So-

Welds 55 mi. gas line—two 40-volt welders on TD-14 provide power for stringing line, Seneca, West Virginia, to Woodstock, Virginia. Pipeline Construction & Drilling Company, Camp Hill, Pennsylvania, weld 2,500 feet daily with this rig.

Clears 50-ft. right-of-way—Clearing on same job described left is being done by TD-24 shown, plus 2 TD-18's and 2 TD-9's. Despite rough, rocky, mountainous terrain and 4500-ft. altitude, fleet clears an average of ½ mile per day.

"Best for backfilling" says R. M. Paylor, Pipeline Construction & Drilling Co. foreman, of International Drott TD-9. "It has highest reach and best balance of any equal-size loader. Hydro-spring sure saves wear in rough rock work."

International Industrial Power

INTERNATIONAL HARVESTER

A machine size for every job . . . see your nearest INTERNATIONAL DISTRIBUTOR for details.

SCRAPERS

CRAWLER TRACTORS

DIESEL, GAS ENGINES

Also International Drott Loaders . . . International Wheel Tractors . . . International Scrapers, Bottom-Dumps . . . Wire Rope and Other Supplies.

Personals

▸ **Col. T. H. Barton,** former chairman of the board of Lion Oil Company, which was merged recently with Monsanto Chemical Company, has been elected a member of the finance committee for Monsanto.

▸ **Arthur M. Sherwood** has been appointed assistant secretary of Socony Mobil Oil Company, Inc. He had served as legal counsel since joining Socony Mobil in 1954. Sherwood was graduated from Harvard University and Columbia University School of Law in 1939.

A reorganization of the overseas operations of Socony will take place effective January 1, with the establishment of a wholly owned affiliate, Mobil Overseas Oil Company, Inc.

Officers and directors of the Mobil Overseas Oil Company have all been chosen from senior members of the Socony Mobil group. President will be **P. V. Keyser Jr.,** who will continue as a director and vice president of Socony Mobil. Others will be: **F. S. Cooper Jr.,** director and vice president in charge of marketing; **W. G. Corwin,** director in charge of producing; **A. V. Danner,** director and vice president in charge of crude and wholesale sales; **A. C. Ingraham,** director and vice president in charge of supply and distribution; **R. R. Jackson,** director in charge of manufacturing; **W. L. King,** director and general counsel; **F. E. Powell Jr.,** director and vice president in charge of marine trade; **J. H. B. Wellacott,** director in charge of finance; **A. L. Lanckton,** secretary; **E. J. Glocke,** comptroller, and **F. L. White,** treasurer.

Orin Atkins

▸ **Orin Atkins** has been named executive assistant to the management of Ashland Oil & Refining Company.

Atkins has been a member of the legal staff of Ashland Oil & Refining since 1950, coming there immediately after his graduation from the law school of the University of Virginia. He was born in Huntington, West Virginia, and attended Marshall College before and after his service in the U. S. Army.

In addition to his studies at the University of Virginia Law School, Atkins was editor of the Reading Guide and president of Delta Theta Phi legal fraternity. He was a member of the University Advisory Council and of Theta Chi social fraternity.

▸ **R. E. Kellerman,** general manager of Texas Crude Oil Company, Dallas, Texas, has been named a partner in the firm. Prior to joining the company, he had been associated with Dowell, Inc., Shell Oil Company and Republic Natural Gas Company.

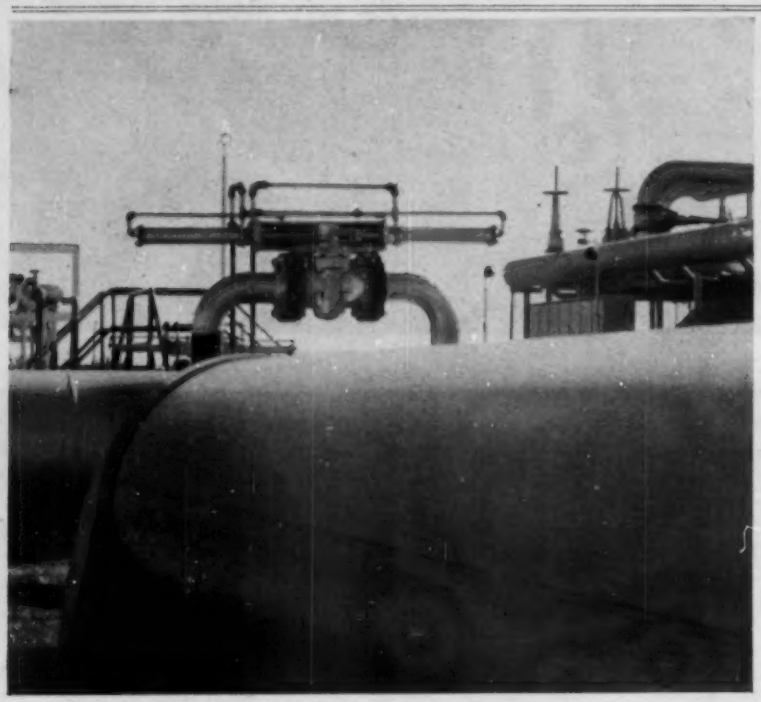
▸ **Stanley Klespert** has been elected president of the newly formed Pam Oil Company, Denver, Colorado. **Warren Hofstra** is geologist and **Reuben Kock** office manager.

▸ **Richard Rollins,** public relations director and secretary of the Atlantic Refining Company, is the new chairman of the national Oil Industry Information Committee.

Rollins succeeds **W. R. Huber** of Gulf Oil. An Atlantic employee since 1919, Rollins is a director and vice president of the Greater Philadelphia Chamber of Commerce and a director of the Pennsylvania Economy League.

▸ **N. L. Grant** will head the new firm of Massac Petroleum Company as president. Other officers are **Louis G. Herman,** vice president, and **Mrs. Grant,** secretary-treasurer.

▸ **George Koegler,** executive assistant to the chairman of the board, has been named deputy general counsel of Standard Oil Company (New Jersey). **E. F. Johnson,** general counsel of the company, has elected to retire in 1956, on completion of 30 years service, to resume general law practice, and Koegler will succeed him at that time. Koegler is a graduate of Lehigh University and Columbia Law School. He joined the Jersey Standard legal department in 1943.



AUTOMATIC BLOWDOWN SYSTEM FOR COMPRESSOR STATION OPERATED BY LEDEEN VALVE ACTUATORS

New AGA Code Revision Specifies Emergency Shutdown Facilities...

"Each transmission compressor station shall be provided with an emergency shutdown system by means of which all gas compressing equipment, all gas fires, and all electrical facilities in the vicinity of gas headers and in the compressor building can be shut down and the gas can be blocked out of the station and the station gas piping blown down." (per Paragraph 843.431, Emergency Shutdown Facilities, Revision of Section B of ASA B31.1).

WRITE FOR BULLETIN 3020.

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VALVE ACTUATORS
AIR HYDRAULIC
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Ledeen Mfg. Co.
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20-TON lift capacity with Koehring 405 crane

Take another look at the heavy-duty crane shown here. It's the new 405 — latest addition to the Koehring line — and brings you a big advantage in *extra work capacity*. For example — with one of these 405's you're equipped to lift any load up to 20 tons. Boom lengths range from 40 to 90 feet. For added reach, 15 to 30-foot jib can be used on any length boom up to 80 feet. This gives you a maximum boom and jib of 110 feet.

Extra lift capacity and stability as a crane increases the Koehring 405's *work capacity* with all attachments. It handles 1 to 1½ yard clamshell or dragline buckets on a wide work radius — readily converts to 1-yard shovel or hoe. Here are some of the heavy-duty features that help you get more work done with every attachment: Big power clutch requires only 1/10th the lever pull of a comparative-size manual clutch — yet retains accurate "feel" of load. Automatic traction brakes also simplify operation — are engaged at all times, except when tractive power is applied — lock and hold the 405 when working or parked. Maintenance is simplified, too. There are only 2 main shafts in the 405's upper machinery. Each assembly is an independent unit with fully enclosed gears, and splined shafts rotating on anti-friction bearings. For more complete details, see Koehring distributor, or write for bulletin.

mail to:

KOEHRING Co., 3026 W. Concordia, Milwaukee, 16, Wis.

Send us ☐ spec. sheets ☐ bulletin on Koehring 405.

NAME_____

TITLE_____

COMPANY_____

DIVISION_____

STREET_____

CITY, STATE_____

K560 PE

Subsidiaries: [illegible]

DEATHS

Gerald G. Lipke, sales manager for standard products, Hagan Corporation, Pittsburgh, Pennsylvania, and his wife were among the 44 persons killed in the explosion and crash of an airliner in Colorado on November 1. Lipke joined the Pittsburgh instrument and control firm in 1936 as a service engineer for Hall Laboratories, Inc., a Hagan subsidiary. He was named sales manager of standard products in 1954.

William W. Brown, former manager of bar sales and coke oven products for The Youngstown Sheet and Tube Company, died on October 22nd in West Palm Beach, Florida, where he had been living for about a year. He had been a Youngstown employee for 42 years and a product manager from 1931 until his retirement in 1954. Brown attended Western University of Pennsylvania, now the University of Pittsburgh.

Willis Stewart, pioneer Los Angeles, California, oil man and retired treasurer of the Texas Company, died October 11 at his home in Los Angeles. He became affiliated with the Doheny American Petroleum Company and served as treasurer and vice president. When American Petroleum became California Petroleum, Stewart continued as vice president. He served as treasurer until his retirement in 1939.

Walter F. Buaas, pioneer Kern County, California, oil man, died recently in Reno, Nevada. A native of Texas, Buaas worked for several oil companies in the Mid-Continent area before going to California. In 1921, he formed the Taft Drilling Company, a pioneer contract drilling firm in Kern County. At the time of his death, he was owner and president of the Buaas Drilling Company of Bakersfield, California.

Ralph C. Warner, former treasurer and member of the board of directors of Standard Oil Company of California, died October 30 in a hospital at Oakland, California. Warner, who retired from Standard in 1930, began in the oil business with the Buckeye Pipe Line Company in Ohio and joined Standard early in the century. He became a director and treasurer in 1920.

R. E. Heithecker, who made a name for himself in petroleum engineering while with the U.S. Bureau of Mines, died October 21 in Dallas, Texas, from leukemia. He was also formerly associated with Seaboard Oil & Gas Company and at the time of his death was a consultant.

Charles L. Bernard, Tulsa, Oklahoma, retired Oklahoma division manager of the Pure Transportation Company, died November 27 in an Independence, Missouri, hospital from a heart attack. After 38 years with the Pure Oil Company and affiliated firms, he retired about a year ago. Bernard attended the University of New Mexico.

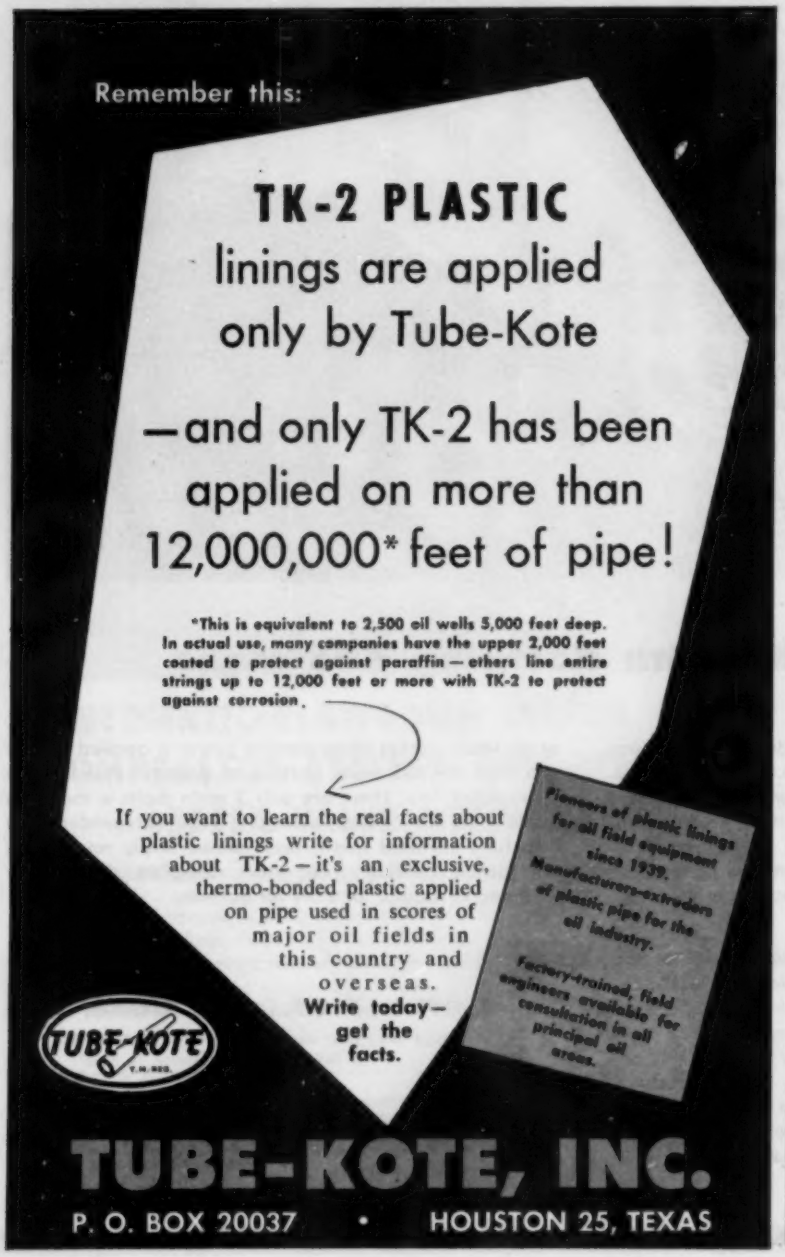
Grady H. Vaughn, Sr., independent oil well drilling contractor and producer, died November 8 at his home in Dallas, Texas, after a heart attack. He was president of the G. H. Vaughn Production Company. Vaughn began in the oil industry as a tool pusher for the Texas Company and also worked for the Gulf Refining Company early in his oil career.

A. B. Johnson, former chief engineer of The Ohio Oil Company's pipe line department, died November 26 at a hospital at Clearwater, Florida, from a heart attack. A graduate in civil engineering from the University of Minnesota, he rose from assistant chief engineer for the company's Wyoming pipe line division, Casper, in 1918 to chief engineer for the company's entire system in 1942. He served in that capacity until his retirement in 1953.

M. A. Abernathy, senior vice president and director of United Gas Corporation, died November 2 in Shreveport, Louisiana, after a brief illness resulting from a heart attack. He was civil engineering graduate of Texas A&M College.

Charles Willis Hughes, Louisiana oilman and manager of the production division of Arkansas Fuel Oil Corporation, suffered a fatal heart attack at his home in Shreveport, Louisiana, December 8. He received a BS in engineering from the University of Missouri. In 1929, Hughes joined the Louisiana Oil Refining Corporation, predecessor of Arkansas Fuel Oil Corporation, and was named manager of the production division in 1953.

Merle Thorpe, 76, founder of *Service Magazine* in 1944 and director of business development for Cities Service Company, died October 31. Best known for the magazine he founded in 1916, the *Nation's Business*, Thorpe was also noted for his work as a businessman, author, newsman and radio commentator.


Remember this:
TK-2 PLASTIC
linings are applied only by Tube-Kote
—and only TK-2 has been applied on more than 12,000,000* feet of pipe!
*This is equivalent to 2,500 oil wells 5,000 feet deep. In actual use, many companies have the upper 2,000 feet coated to protect against paraffin — others line entire strings up to 12,000 feet or more with TK-2 to protect against corrosion.
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LAUGH with BARNEY

A gentle Quaker, hearing a noise in the house, rose from his bed and investigated. With his gun, he stood quietly in the doorway and confronted a burglar. "Friend," he said, "I would do thee no harm for the world, but thee standest where I am about to shoot."

* * *

Two Texas ranchers, in Chicago on business, were invited to attend a masquerade ball. On their arrival, one of them spied a girl masquerading as a map of Texas and immediately asked her for a dance.

Shortly afterward his companion noticed that he was standing in the middle of the dance floor, looking completely bewildered, while the girl was walking angrily away.

Going over to his friend he asked, "What happened? What did you do?"

"Nothing. I didn't do nothing," was the reply. "When she asked me where I came from I put my finger on Amarillo, then she slapped me and walked off!"

* * *

An Irishman named Mike Flannery found a valuable package belonging to a local capitalist. He took it around to the man's house and was rewarded. As he left he met a friend.

"What's the matter, Mike?" asked the friend. "Didn't he give you as much as you expected?"

Flannery looked up sourly and replied: "I thought he would give me more than I expected!"

* * *

A man was introduced to a circus sword-swallower. Not having seen a sword-swallower before, he asked him to demonstrate his art, whereupon the fellow apparently swallowed some pins and needles.

"But," protested the man, "Those aren't swords—they're pins and needles."

"I know," was the reply, "I'm on a diet."

* * *

Two farmers went fishing one day, and when they got home, they compared their experiences. One said he had caught a 200-pound salmon. The other called his attention to the fact that salmon never weigh 200 pounds, but the first stuck to what he claimed. Then he asked:

"What did you catch?"

"Well," was the reply, "all I got was a rusty old lantern bearing the inscription 'Captain Kidd, 1756', and, would you believe it, there was a lighted candle inside it."

The first fisherman gulped, cleared his throat, and said:

"Looka here. Let's get together on our fish stories. I'll take 100 pounds off my salmon if you'll put out the candle in that there lantern."

They had searched in vain for a hotel room in the big city. "Well, mother," he said wearily, "I guess we'll have to sleep in one of those night clubs, even if they do charge $5 for covers."

* * *

Wife: My husband has no bad habits whatsoever. He never drinks, and he spends all his evenings at home. Why he doesn't even belong to a club.

Friend: Does he smoke?

Wife: Only in moderation. He likes a cigar after he has a good dinner, but I don't suppose he smokes two cigars a month.

* * *

Little Jimmy, aged six, and the girl next door, age five, were sweethearts. One day he asked her to marry him. She accepted and thus engaged they went over to her house to play. They went into the kitchen, got out all the pots and pans, and the sugar, and the flour, and eggs, and milk, and in ten minutes, ho, what a lovely mess.

Then the little girl's mother appeared. She could hardly believe her eyes. "Get out of here," she screamed. "Get out. Get out."

The little girl shot out of the back door like greased lightning. The terrified boy followed but before he disappeared down the back steps he gathered enough courage to turn around and shout at the top of his lungs, "Boy, what a lousy mother-in-law you're going to make."

* * *

Patron at the bar ordered a dry martini and watched with critical eyes as the bartender deftly added a twist of lemon peel. The customer immediately let out a shriek of protest. "If I'd wanted lemonade I would have ordered it."

* * *

A Texas GI was playing poker with some English soldiers. He drew four aces. "One pound," ventured the Englishman on his right.

"Ah don't know how you'all count your money," said the Texan, "but ah'll raise you a ton."

* * *

"I can't sleep," wailed a voice in his ear, as the doctor got out of bed to answer the telephone at three in the morning.

"Hold the phone," said the doctor crustily. "I'll sing you a lullaby."

* * *

The motorist and his wife had an argument and hadn't said a word for many miles. Suddenly the man saw a mule in a pasture they were passing; and pointing to it, asked: "Relative of yours?"

"Yes," she replied, " by marriage."

It has finally been determined what is meant by the hammer and sickle on the Russian flag. The sickle is to mow 'em down and the hammer is to keep 'em that that way.—*McCall Spirit,* McCall Corp'n.

* * *

Pat and Maggie had been driving for almost an hour through a lonely country road. No word had been spoken. The rattle of the car and the hum of the motor was all that broke the stillness. Suddenly Pat looked at Maggie and muttered in a quiet, unemotional voice: "Maggie, will you marry me?"

Maggie, showing some emotion, answered in the affirmative.

The speed of the car was not broken. For the next half hour not a word was spoken.

Growing impatient, Maggie finally looked at Pat and asked: "Pat, ain't you going to say nothing else?"

"Nope," came the answer, "Said too darn much already!"

* * *

The fountain of youth, these days, is the one where they dispense sodas and cokes.

* * *

The distraught, henpecked husband was on the psychiatrist's couch.

"How would you describe your wife?" asked the analyst.

"She's the woman of my dreams," was the reply.

"Well, if she's that, why did you tell me that she's making your life miserable?"

"Because, doctor, I have such terrible dreams!"

* * *

"Are there any cavities in my teeth, doctor?"

"Just where do you think that echo is coming from?"

* * *

"When I applied for that job, the manager had the nerve to ask if my punctuation was good!"

"I said I'd never been late for work in my life!"

* * *

Family pride in an athletic son can reach great heights, but it was equalled by the partisanship of one father for the local team in which his son played scrubhalf.

When an important match was being played some distance from home, he asked his son to wire the result.

That evening the telegram came, bearing the curt message: "Collarbone and one rib broken."

"Yes, yes," exclaimed the father, impatiently, "but he doesn't say who won."—*Tit-Bits,* London.

ALL NEW DESIGN!

Simple...Foolproof...Low Cost

1500 WATT HOMELITE GENERATOR

Model 35A115
Homelite Generator
1500 Watts, 115 Volt
60 Cycle AC

As easy to move as an electric hand saw!

1. New Money-Saving features . . . No DC brushes; just two easy-to-get-at collector ring brushes . . . No commutator or DC windings . . . No intermediate couplings; armature keys directly to shaft. Fewer parts to wear out — longer trouble-free generator service.

2. Constant Voltage . . . less than 4% change from no load to full 1500 watt capacity . . . assures long service life for your electric tools . . . guarantees top performance at all times.

3. Overload Capacity . . . 1500 watt continuous duty with generous overload capacity prevents tool stalling under heavy loads . . . insures uninterrupted service even when starting loads exceed operating loads.

4. Compact and Lightweight . . . one man can easily carry this generator wherever you need electricity to power time-saving electric tools. No need for long, hazardous power-consuming cables.

Whatever tools you want to operate — electric saws, drills, floodlights, grinders, belt sanders, hammers, — the new Homelite 35A115 generator can save you money. For a free demonstration or additional information, call your nearest Homelite representative, or write:

SAVE EVEN MORE! New Homelite electronic idle control unit, available as optional accessory, runs engine at idle speed when no current is drawn . . . automatically brings engine to full speed when load is applied.
Ask your Homelite representative to show you how this easily-installed accessory reduces engine wear . . . increases service life . . . cuts fuel consumption.

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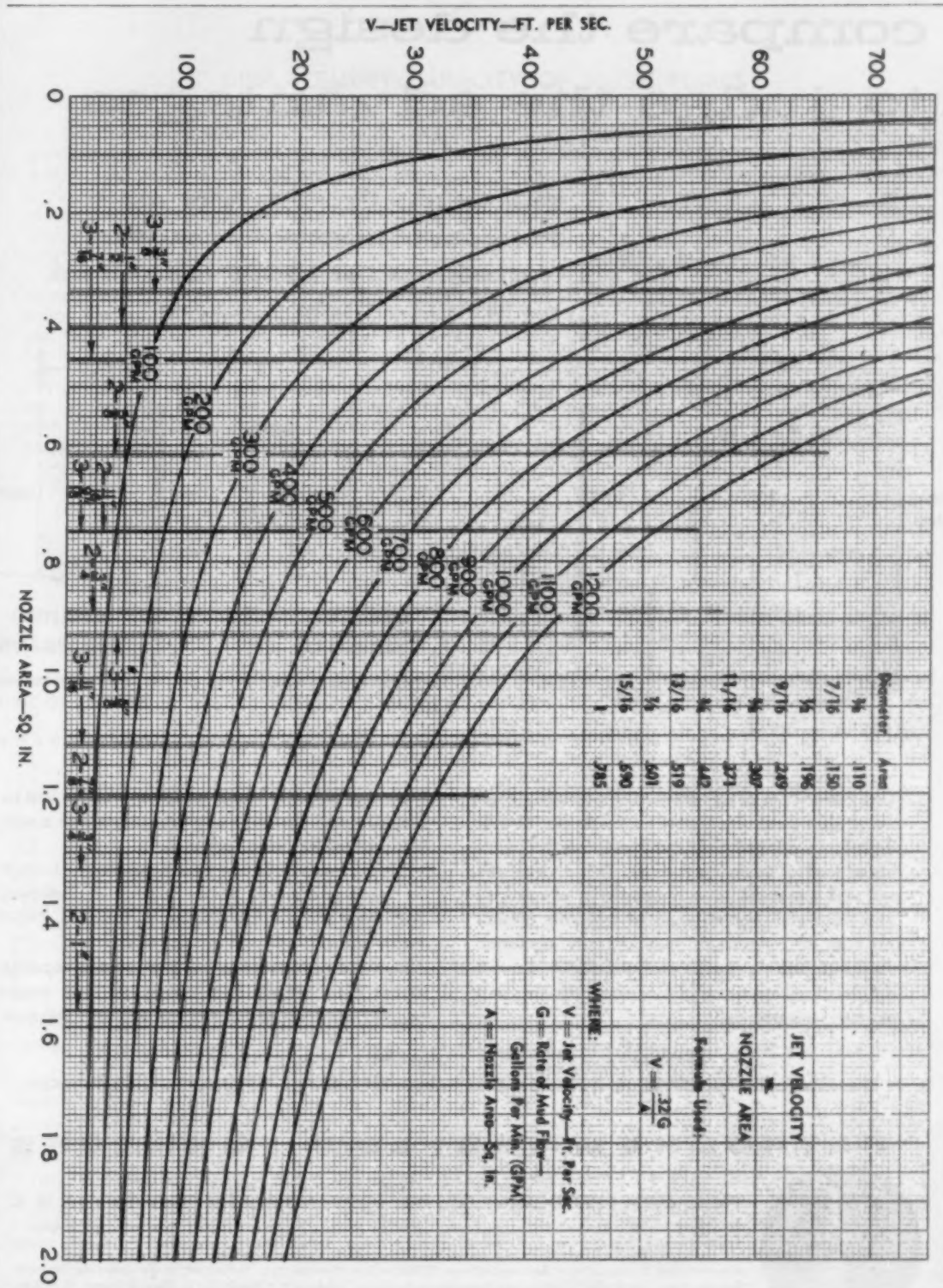
Manufacturers of Carryable PUMPS • GENERATORS • BLOWERS • CHAIN SAWS

DRILLING HYDRAULICS



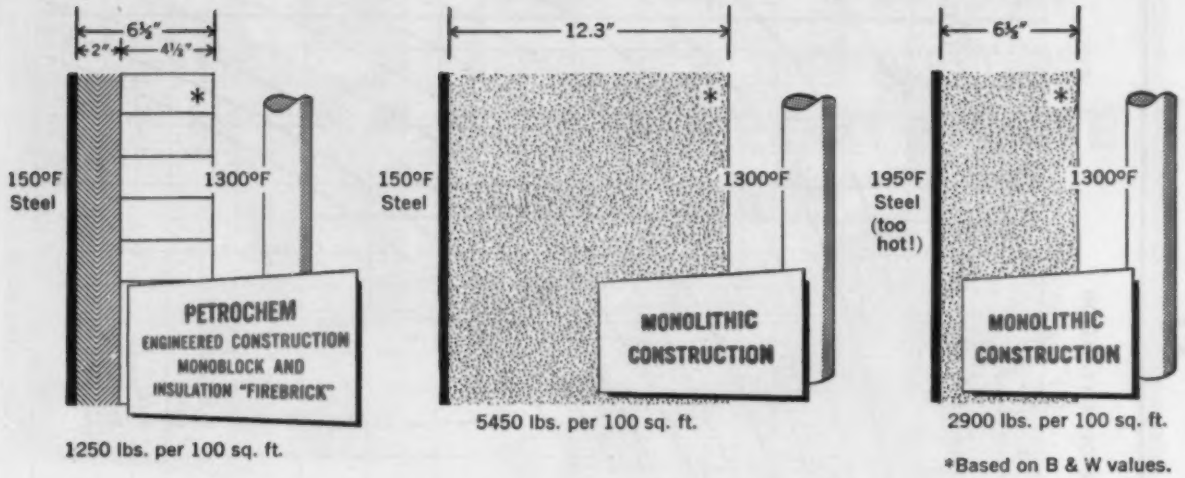
Courtesy of Hughes Tool Company

CUT ALONG THIS LINE FOR YOUR PERSONAL REFERENCE FILE.

In furnaces as in processes compare the design to judge the advantages

As an example:

The wall construction of all Petrochem-Isoflow Furnaces is designed for 150°F maximum outside shell temperature.



*Based on B & W values.

The Petro-Chem design provides a thoroughly engineered wall construction. It is built with two tiers of monoblock supported on 18 inch centers and a circular arched wall of insulating firebrick. The inside of the steel shell is protected from the possibility of corrosion by a one-eighth inch thickness of Staylastic cement. This type of construction, independently supported monoblock and the circular arch of firebrick, bonded with Smoothset mortar, assures optimum efficiency and minimum maintenance.

The use of monoblock and insulating firebrick laid as a circular arch provides many advantages over a one-piece monolithic lining, including:

1—Low weight, 2—Low heat conductivity, 3—High hot crushing strength, 4—Low expansion coefficient, 5—Resilient compressible backing, 6—Long life, 7—Nil maintenance.

Also, this construction has low heat storage capacity, speeds both heating and cooling. Its light weight requires less concrete foundations and steel supports.

Compare and your judgment will affirm
Petrochem-Isoflow Furnaces are Most Efficient by any Comparison

PETROCHEM-ISOFLOW FURNACES

UNLIMITED IN SIZE . . . CAPACITY . . . DUTY

PETRO-CHEM DEVELOPMENT CO., INC. • 122 EAST 42nd St., New York 17, N. Y.

REPRESENTATIVES: Rawson & Co., *Houston* • Wm. H. Mason Co., *Tulsa* • Lester Oberholtz, *Los Angeles* • Faville-Levally, *Chicago* • D. D. Foster, *Pittsburgh* • Turbex, *Philadelphia* • Flagg, Brackett & Durgin, *Boston*

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DRILLING HYDRAULICS

DISPLACEMENT CAPACITY OF SLUSH PUMPS

Following curves show theoretical displacement capacity for duplex, double-acting slush pumps with various stroke lengths and liner sizes. The data is plotted as theoretical displacement in gallons per minute versus strokes per minute. Charts are included for 12, 14, 15, 16, 18, 20 and 22 inch stroke length.

A table shows the theoretical displacement of duplex, double-acting slush pumps per inch of stroke length for various liner sizes. The theoretical displacement for pump sizes not covered by the charts can be readily determined from this data as explained in example shown on the table.

The values of displacement shown on the charts and in the table are based upon 100% volumetric efficiency, deduction having been made for piston rod sizes as shown. The actual delivery from slush pumps will be less than the theoretical values shown due to slippage of the fluid past the pistons and valves. Ordinarily a deduction of about 5% is made for slippage at slow speeds (under 40 strokes per minute) and about 10% at higher speeds (40 strokes per minute or greater).

It should be pointed out that the operating stroke of steam pumps frequently is not as great as the nominal stroke length of the pump. It is therefore necessary to measure the stroke length the pump is making during operation in order to accurately determine the actual displacement obtained under these conditions In the case of power pumps, however, the actual stroke length will be the same as the nominal length shown on the pump.

To determine the displacement for triplex pumps, multiply the displacement for duplex pumps of same size and operating speed by 1.5.

THEORETICAL DISPLACEMENT OF DUPLEX, DOUBLE-ACTING SLUSH PUMPS

Liner Diameter, Inches	Theoretical Displacement—Gallons Per Inch of Stroke Length*							
	Fluid Piston Rod Diameter—Inches							
	1½"	1¾"	1⅞"	2"	2¼"	2½"	2¾"	3"
.....	0.2021	0.1962	0.1936	0.1900	.....	.....	.....	.....
4¼	0.2300	0.2245	0.2215	0.2180	.....	.....	.....	.....
4½	0.2600	0.2540	0.2512	0.2380	0.2410	.....	.....	.....
4¾	0.2910	0.2860	0.2823	0.2792	0.2720	.....	.....	.....
5	0.3248	0.3192	0.3161	0.3128	0.3056	0.2976	.....	.....
5¼	0.3595	0.3539	0.3508	0.3475	0.3403	0.3323	.....	.....
5½	0.3962	0.3906	0.3875	0.3842	0.3770	0.3690	0.3600	.....
5¾	0.4344	0.4288	0.4257	0.4224	0.4152	0.4072	0.3982	.....
6	0.4744	0.4688	0.4657	0.4623	0.4551	0.4471	0.4381	0.4284
6¼	0.5160	0.5104	0.5073	0.5040	0.4968	0.4887	0.4798	0.4700
6½	0.5593	0.5537	0.5506	0.5473	0.5402	0.5320	0.5230	0.5132
6¾	0.6043	0.5988	0.5957	0.5924	0.5852	0.5771	0.5680	0.5582
7	0.6511	0.6255	0.6424	0.6391	0.6319	0.6239	0.6149	0.6051
7¼	0.6996	0.6940	0.6909	0.6876	0.6804	0.6723	0.6634	0.6536
7½	0.7498	0.7442	0.7411	0.7378	0.7306	0.7225	0.7136	0.7038
7¾	0.8016	0.7960	0.7929	0.7896	0.7824	0.7743	0.7654	0.7556
8	0.8552	0.8496	0.8465	0.8432	0.8360	0.8280	0.8191	0.8093
8¼	.....	0.9048	0.9017	0.8984	0.8912	0.8831	0.8740	0.8642
8½	.....	.....	0.9587	0.9554	0.9482	0.9402	0.9313	0.9215
8¾	.....	.....	.....	1.0140	1.0068	0.9988	0.9898	0.9800
9	.....	.....	.....	.....	1.0672	1.0592	1.0502	1.0404
9¼	.....	.....	.....	.....	.....	1.1212	1.1122	1.1024

* Note: Displacement per inch of stroke length .. displacement of one inch of forward and one inch of return stroke of both pistons. To determine the theoretical displacement of a duplex pump operating at a given speed, multiply value shown in table under proper liner size and piston rod diameter by the stroke length in inches and by the number of strokes per minute.

Example: Determine the theoretical displacement from a pump with 6" diameter liners, 1⅞" diameter piston rods, 10" stroke length and operating at 50 strokes per minute.

From table: Displacement per inch of stroke length = 0.4657 gallons. Then: Total theoretical displacement = 0.4657 x 10 x 50 = 232 gal./min.

If Table is to be used for triplex pumps; multiply displacement values by 1.5.

Courtesy of Hughes Tool Company

Specify CHAPMAN STEEL VALVES

in any of the Standard Alloys

to meet your steel valve needs

When you specify Chapman Steel Valves you also specify steels designed for your specific services. Standard alloy steels match every normal industrial requirement. Special alloys can be furnished for extraordinary service conditions. All metals are poured in Chapman's own foundries under rigid laboratory supervision.

Exceptionally close machining tolerances are another standard feature of Chapman Steel Valves. Under the most severe conditions, Chapman Steel Valves seat tightly and positively, without jamming, chattering, or wearing excessively. Operation remains smooth and dependable; maintenance costs stay low.

See Chapman *first* for gates, globes and checks in all pressure classes — 150, 300, 400, 600, 900, 1500 and 2500 pounds — and for temperatures to 1150°F. Valves are available with welded, pressure seal, or bolted bonnet joints and with flanged or welding ends. ASA standards are equalled or exceeded in every range. Write for Catalog 20.

THE CHAPMAN VALVE MANUFACTURING COMPANY
INDIAN ORCHARD, MASSACHUSETTS

UNIVERSAL CONVERSION FACTORS

FOOT PER MINUTE (Continued)

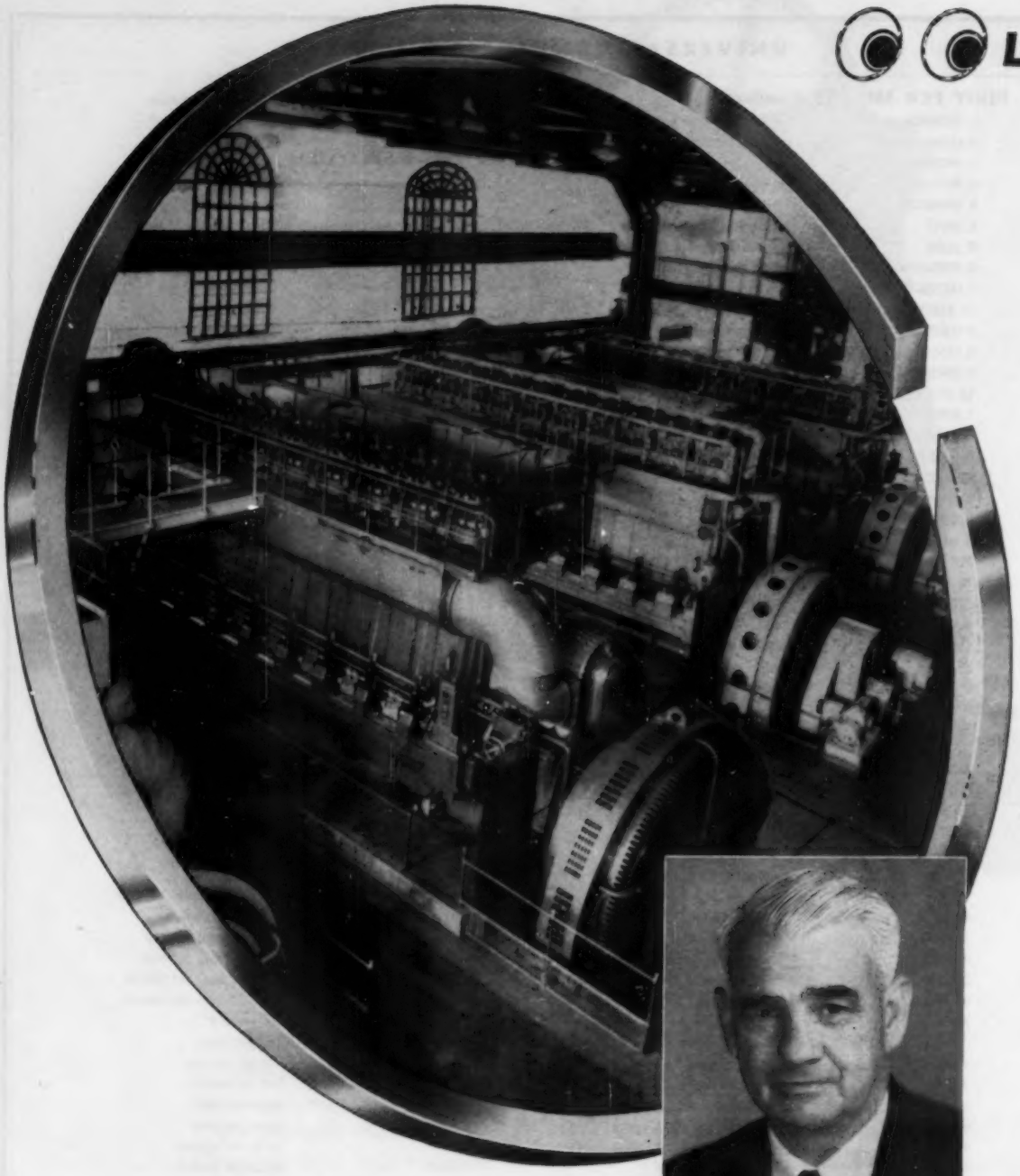
0.00000508	kilometers per second
2.18182	furlongs per day
0.090909	furlongs per hour
0.0015151	furlongs per minute
0.000025253	furlongs per second
4.38913	hektometers per day
0.18288	hektometers per hour
0.003048006	hektometers per minute
0.0000508	hektometers per second
21.81818	chains per day
0.90909	chains per hour
0.015151	chains per minute
0.00025253	chains per second
43.89129	dekameters per day
1.82880	dekameters per hour
0.03048006	dekameters per minute
0.000508	dekameters per second
87.27273	rods per day
3.63636	rods per hour
0.0606061	rods per minute
0.0010101	rods per second
438.91286	meters per day
18.28804	meters per hour
0.3048006	meters per minute
0.00508	meters per second
480.0	yards per day
20.0	yards per hour
0.33333	yards per minute
0.0055556	yards per second
518.400	varas (Texas) per day
21.60	varas (Texas) per hour
0.3600	varas (Texas) per minute
0.0060000	varas (Texas) per second
1,440.0	feet per day
60.0	feet per hour
1.0	feet per minute
0.016667	feet per second
1,920	spans per day
80.0	spans per hour
1.33333	spans per minute
0.022222	spans per second
2,181.81818	links per day
90.90909	links per hour
1.51515	links per minute
0.025253	links per second
4,320	hands per day
180.0	hands per hour
3.0	hands per minute
0.050000	hands per second
4,389.12864	decimeters per day
182.88036	decimeters per hour
3.048006	decimeters per minute
0.050800	decimeters per second
43,891.2864	centimeters per day
1,828.80360	centimeters per hour
30.48006	centimeters per minute
0.50800	centimeters per second
17,280	inches per day
720	inches per hour
12.0	inches per minute
0.20000	inches per second
438,912.864	millimeters per day
18,288.0360	millimeters per hour
304.8006	millimeters per minute
5.08001	millimeters per second

FOOT PER SECOND =

16.36363	miles per day
0.68182	miles per hour
0.011364	miles per minute
0.0001893939	miles per second
26.33477	kilometers per day
1.097282	kilometers per hour
0.018288	kilometers per minute
0.0003048006	kilometers per second
130.90909	furlongs per day
5.45455	furlongs per hour
0.090909	furlongs per minute
0.0015151	furlongs per second
263.34772	hektometers per day
10.97282	hektometers per hour
0.18288	hektometers per minute
0.003048006	hektometers per second
1,309.09090	chains per day
54.54545	chains per hour
0.90909	chains per minute
0.015151	chains per second
2,633.47718	dekameters per day
109.72823	dekameters per hour
1.82880	dekameters per minute
0.03048006	dekameters per second
5,236.36364	rods per day
218.18182	rods per hour
3.63636	rods per minute
0.0606061	rods per second
26,334.77184	meters per day
1,097.28216	meters per hour
18.28804	meters per minute
0.3048006	meters per second
28,800	yards per day
1,200	yards per hour
20.0	yards per minute
0.33333	yards per second
31,104	varas (Texas) per day
1,296.0	varas (Texas) per hour
21.60	varas (Texas) per minute
0.3600	varas (Texas) per second
86,400	feet per day
3,600	feet per hour
60	feet per minute
1	feet per second
115,200	spans per day
4,800	spans per hour
80.0	spans per minute
1.33333	spans per second
130,909.090909	links per day
5,454.54545	links per hour
90.90909	links per minute
1.51515	links per second
259,200	hands per day
10,800	hands per hour
180.0	hands per minute
3.0	hands per second
263,347.7184	decimeters per day
10,972.8216	decimeters per hour
182.88036	decimeters per minute
3.048006	decimeters per second

Compiled by Steven Gerolde, Gulf Oil Corporation

CUT ALONG THIS LINE FOR YOUR PERSONAL REFERENCE FILE.



William E. Van Deusen
Chief Engineer

to COOK for Better Rings!

COOK Piston Rings Help Rockville Centre Diesel Average Less Than .001" Cylinder Wear Per 1000 Hours!

SINCE 1928, the Rockville Centre (N. Y.) municipal power plant has consistently racked up some of America's most impressive performance records.

The performance of its No. 8 unit — a Nordberg Type TS-21-9 — is typical. After 25,037 operating hours *(2.86 years!)* inspection of the cylinders revealed the following:

1. Liners were in excellent condition — clean and free of lacquer and carbon.
2. While several rings were renewed in Grooves 1 and 2, no rings were renewed in Grooves 3, 4, 5 and 6, and these can run for an additional 10,000 hours.
3. *Cylinders averaged less than .001" maximum wear per 1000 hours of operation!*

This record is a tribute to Rockville Centre's management and operating personnel, and C. Lee Cook piston rings.

If you're looking for a seal with the savings built in, mail the coupon for product information and the name of your nearest C. Lee Cook representative.

TENSION THAT NEVER WEARS OUT!

Cook Piston Rings are tensioned on a Cook-designed machine which accurately controls the amount and distribution of tension. This exclusive process gently "squeezes" tension into the rings, with a series of small indentations—avoids harmful disarrangement of the rings' molecular structure. *The result is constant, uniform tension that never wears out!*

C. LEE COOK COMPANY

Sealing Pressures Since 1888

C. Lee Cook Company
916 South 8th Street
Louisville 3, Kentucky

Gentlemen: Please send me complete information on Cook Piston Rings and name of nearest representative.

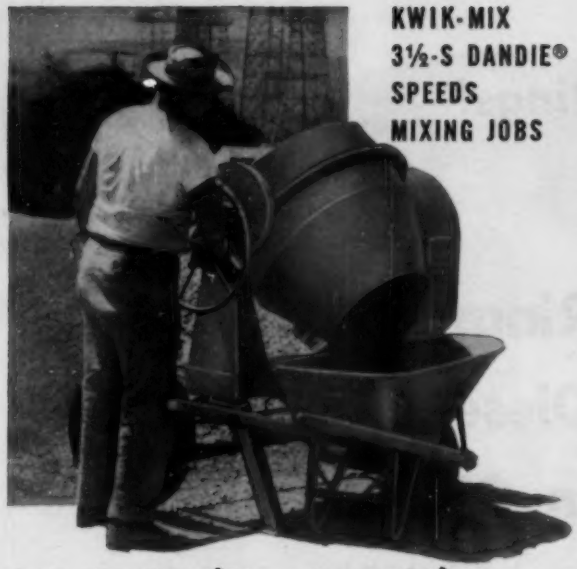
Firm _____

Street _____

City _____ State _____

Attention _____

Type of Units _____



KWIK-MIX 3½-S DANDIE® SPEEDS MIXING JOBS

Oil field "handyman"

For pouring footings, laying concrete slabs, and handling all other widely-scattered mixing jobs around refineries, yards, booster stations or drill sites, here's a portable "handyman" that does on-the-spot mixing. Kwik-Mix 3½-S Dandie produces high-quality concrete fast, at low cost, anywhere on your property.

IT'S AS PORTABLE AS A WHEELBARROW....

Balanced light weight, low center of gravity, roller-bearing wheels, and handy push-down tow-pole provide easy one-man spotting on the job . . . and give smooth, fast towing job-to-job. Low charging height is only 43 inches. Easy-tilting drum is self-locking in any discharge position. The all-welded steel drum has reinforced lip, separate ring gear, and box-section yoke for long-wearing durability. This utility-size 3½-S Dandie also has multiple V-belt drive, standard 3.4 h.p. air-cooled gas engine, antifriction bearings throughout. It's available in 3 models: end-discharge tilter (shown here), end-discharge non-tilt, and a side-discharge tilter.

See your Kwik-Mix distributor for full details, or send for bulletins on this 3½-S, or on the larger 6-S, 11-S, 16-S sizes.

• • • •

OIL and GAS TRADE NEWS

Jet Research Company Formed

Formation of a new corporation, Jet Research Center, Inc., has been jointly announced by Welex Jet Services, Inc., and the Byron-Jackson Division of the Borg-Warner Corporation.

The new corporation, which will have its home offices in Arlington, Texas, will be jointly owned by the two parent companies.

B. M. Caldwell, formerly Welex vice president for engineering, will be president of the new company. Members of the board of directors will be Ray Shaffer and T. W. Painter of Welex, and Robert Harcus and A. E. Hambly of Byron-Jackson.

Jet Research will conduct original research on jet charge perforating for the two companies. Work will be performed to extend the use of the jet process to other industries.

U. S. Industries New Division

U. S. Industries, Inc., has completed its second acquisition of 1955, that of Southern Pipe & Casing Company, near Azusa, California.

Southern Pipe & Casing, with sales currently running at the rate of about $10,000,000 a year, represents one of USI's largest acquisitions since its diversification program started in 1949. It raises USI's present total annual sales volume to about $100,000,000.

Southern Pipe and Casing becomes a USI division, without change in its management personnel.

Stauffer-Consolidated Merger OK

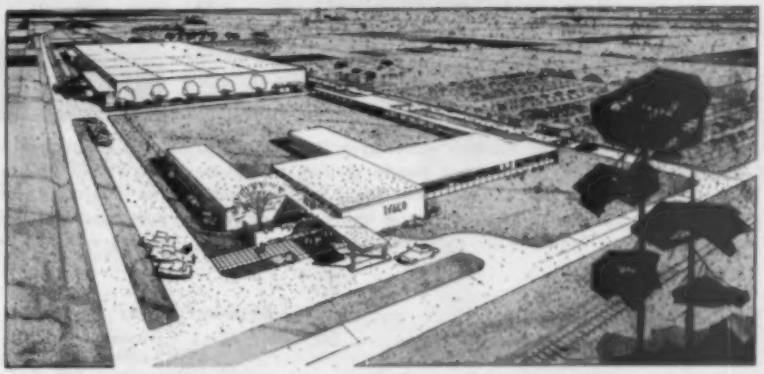
The merger of Consolidated Chemical Industries into Stauffer Chemical Company has been approved by stockholders of both companies.

After the merger, Stauffer Chemical Company will be the surviving corporation.

New Name for Houdaille-Hershey

Houdaille Industries, Inc., is the new name of the corporation which since 1929 has been known as the Houdaille-Hershey Corporation.

Stockholders of the corporation approved the change as being more descriptive of the corporation's widened scope of operations. Executive headquarters of the corporation recently was moved to Buffalo, New York, where four of the company's 12 businesses are located.



Plans and specifications have already been approved for Well Equipment Manufacturing Corporation's new plant in Houston, Texas, with construction bids to be submitted soon. The project consists of a one-story office building, main plant, chip separator and paint storage facilities, and other smaller structures. Work is expected to start on the new plant about January 15, with completion scheduled for mid-year.

Acme Oil Tool Expands

Acme Oil Tool Company, Oklahoma City, Oklahoma, has assumed control of the Me-Tex Supply Company, Hobbs, New Mexico. The Hobbs branch of the tool company will be operated as Acme-Metex Tool Co., Inc., managed by Don Burner.

Burner has been, until recently, chief design engineer for the company. A graduate in petroleum engineering from the University of Tulsa, he has had wide experience in the petroleum industry and was formerly associated with the Skelly Oil Company.

New Wireline Service Company

A new corporation, Great Lakes Petroleum Services, Inc., with main offices in Houston, Texas, has recently been organized as a wholly owned subsidiary of Great Lakes Carbon Corporation of New York City.

The new corporation's objective is to furnish to the oil industry various improved electric wireline services such as perforating and gamma ray-neutron logging.

Officers are J. T. Hancok, Jr., president; R. W. Smith, vice president-manager of sales, and L. W. Toelke, vice president-engineering and development.

Cash Names Representatives

The A. W. Cash Company, has appointed the following new representatives for the Cash standard line of automatic valves, controllers, governors, and regulators: The David J. Rank Company, Louisville, Kentucky; Bert Gurney & Associates, Omaha, Nebraska, and Consolidated Engineering Sales Company, Cincinnati, Ohio.

Air Tool Repair Center

The Cleco division of the Reed Roller Bit Company has opened a new air tool supply and repair center in Dallas, Texas, to provide improved service to operators in the North Texas and Oklahoma areas.

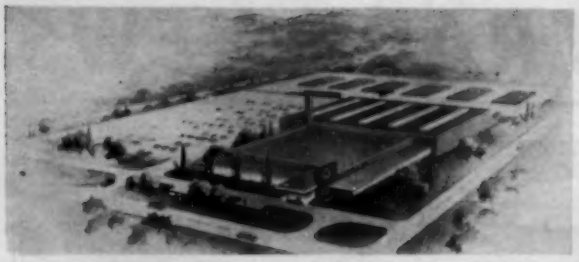
Crystals Being Mass Produced

Mass production of lithium iodide (Europium activated) crystals for slow neutron scintillation detection and measurement has been announced by National Radiac, Inc.

The decision to expand lithium iodide (Europium activated) crystal production was made because of the increasing demand from industry and the laboratories for the most efficient detector of slow neutrons. Shipment of this type of crystal can now be made from stock.

Moving into its recently completed research and engineering center has been accomplished by Fisher Governor Company at Marshalltown, Iowa. The enlarged product engineering department is adjacent to the research laboratory area. Sales engineering, executive offices and general offices are in the building.

Extensive branch facilities have been completed for Le Roi Division of Westinghouse Air Brake Company at its southwestern sales region and petroleum industry headquarters in Tulsa, Oklahoma. Included in the new plant are modification and assembling facilities, a replacement parts store, warehouse and offices.



Ground has been broken for the construction of a new $1,500,000 Jones & Laughlin Steel Corporation supply division headquarters and warehouse in Tulsa, Oklahoma. The 11-acre building site will house the main offices, warehouse and supply store. A large pipe storage area will be provided at the rear.

Jones & Laughlin Steel Corporation has begun operations in its new $1,500,000 research laboratory in Pittsburgh, Pennsylvania. The laboratory was named the Graham Laboratory for J&L Research in honor of Herbert W. Graham, who in over 40 years of service with J&L became a leader in industrial research.

Glidden Painting Analysis

A new cost-free service designed to reduce sharply the losses caused each year by improper maintenance painting has been announced by the Glidden Company. The Glidden "painting analysis" service provides expert technical aid for solving commercial, industrial, and institutional painting problems. This service is offered as a means of curtailing costly maintenance care, improving protection afforded structual members and equipment.

New Distributorship

Macco Oil Tool Company, Houston, Texas, has announced the formation of a new distributorship for South Louisiana and Mississippi.

Name of the company will be "Macco Gas Lift of the Mississippi Delta."

Dual-Completion Rights

Oil Center Tool Company, Houston, Texas, has announced that the company is offering manufacturing rights for dual-completion wellhead equipment under its patent No. 2,335,355 to all valve and wellhead equipment manufacturers on a non-royalty basis.

O-C-T is offering these manufacturing rights because the company believes that the oil industry is entitled to the full benefits of dual-completion equipment and that oil operators should be at liberty to specify the valves and other component equipment without paying royalty.

New Firestone Synthetic Rubber

Pilot plant production for a new type of synthetic rubber that promises to replace natural rubber in truck tires has been announced by The Firestone Tire & Rubber Company.

Patent rights, research data and small experimental quantities of the new rubber have been offered to the Department of Defense and the rubber industry in the national interest.

Pipelife Buys Licensee Company

Pipelife Corporation has announced the purchase of Internal Pipe Line Maintenance Company of Louisiana-Arkansas. This company was the licensee for Pipelife in those two states and will become the southern division of Pipelife.

Lee Holland, former president of Internal Pipe Line, will manage the division as superintendent, with headquarters in Magnolia, Arkansas.

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STEPS

in the right direction!

The Record Publishing Company once again has taken progressive steps in an effort to give the oil and gas industry the *best directory* available in 1956.

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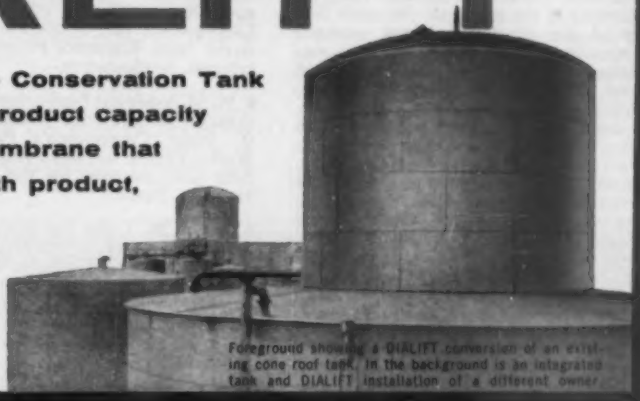
The HAMMOND DIALIFT

The ONLY membrane type Conservation Tank with full-rated vapor and product capacity AT ALL TIMES, with a membrane that cannot come in contact with product, vapor space that can be isolated for inspection and maintenance without taking product storage tank out of service.



Foreground showing a DIALIFT conversion of an existing cone roof tank. In the background is an integrated tank and DIALIFT installation of a different owner.

Principle of the Hammond Dialift

- **A— DIALIFT DIAPHRAGM rises and falls to accommodate expanding and contracting vapor.**
- **B— Vapor passes to and from tank and DIALIFT through simple elbow connection.**
- **C— DIALIFT and tank have full-rated capacity.**
- **D— Membrane can't come in contact with product.**
- **E— DIALIFT can be isolated for maintenance and inspection, product tank stays in service.**

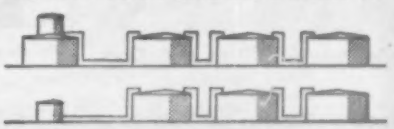
The most efficient and economical vapor conservation system for new or old tanks.

THE HAMMOND DIALIFT consists of a gas-tight Vulcalock membrane attached to the inside periphery of a cylindrical metal housing to become a "breathing" apparatus to accommodate the expanding and contracting vapor as developed in product storage tanks. The DIALIFT can be used as a single conservation unit by being attached to the roof of a product storage tank or as a central "breathing" system by being manifolded to a number of product storage tanks. There are two forms of installation: —Ground type manifolded to a number of tanks to form a conservation system and integrated type whereby the DIALIFT is attached to the roof of a product tank for vapor conservation for one or a number of tanks.

The DIALIFT is completely isolated from the product storage tank. Vapor passes between the tank and DIALIFT through a vaporline connection. It is easy to convert old cone roof tanks to efficient vapor-saving DIALIFT installations by attaching a DIALIFT housing with membrane to the roof of the old tank and connecting the vaporline between the tank and DIALIFT.

New or converted DIALIFT tank, inter-connected with cone-roof tanks, becomes central "breathing" unit.

DIALIFT GROUND UNIT serves as central "breathing" apparatus of multi-tank conservation system.



THE HAMMOND DIALIFT ELIMINATES BREATHING LOSS AND REDUCES FILLING LOSS

Write for catalog 55DL

HAMMOND IRON WORKS

WARREN and BRISTOL, PA. • PROVO, UTAH • CASPER, WYO. • BIRMINGHAM, ALA.

Sales Offices: NEW YORK 20 • AKRON • BOSTON 10 • BUFFALO 2 • CHICAGO 3 • CINCINNATI 2 • CLEVELAND 15 • EL PASO • HOUSTON 2 • LOS ANGELES 14 • PITTSBURGH 19 RICHMOND 20 • SAN FRANCISCO • WASHINGTON 6, D.C. • HAVANA • "TIPSA" BUENOS AIRES

TRADE PERSONALS

▸ **Lester E. Johnson** has joined The International Nickel Company, Inc., as supervisor of the industrial chemicals section of the development and research division in New York City. He will concentrate principally on developments in nickel catalysts and nickel compounds. Johnson holds a BS in electrical engineering from the University of South Dakota and a Master of Engineering Science degree from the University of Cincinnati. Before joining International Nickel, he served as sales manager of the Genesee Research Corporation, a wholly owned subsidiary of Olin-Mathieson Chemical Corporation, and in other sales capacities with the parent company.

▸ **W. K. Harwood,** petroleum engineer, has become associated with The Bovaird Supply Company to serve in an advisory capacity to the staff and management. Harwood was formerly associated with his brother, R. J. Harwood, in the operation and management of the Harwood Oil Company in Wichita, Kansas.

▸ **R. W. Eddy** and **J. J. Morris** have been appointed assistant managers of the fine chemicals division of Carbide and Carbon Chemicals Company, a division of Union Carbide and Carbon Corporation. Eddy has been product manager directing market development of chemical intermediates including acrolein and its derivatives and new chemicals from the company's new Oxo unit. Morris has been product manager directing market development of Flexol plasticizers and stabilizers for vinyl resins.

▸ **Harry N. Strothman** has been appointed regional sales engineer in charge of the new Chicago, Illinois, office of Royston Laboratories, Inc. Strothman was transferred from Royston's Pittsburgh, Pennsylvania, headquarters.

▸ **W. M. Asher** has been named sales manmanager for hydraulic products at the A. O. Smith Corporation's Pacific Coast Works. For the last three years, Asher has been sales manager for the company in Houston, Texas.

▸ **Joseph W. Calby** has joined the Newark, New Jersey, office of Acheson Industries, Inc., as assistant to the technical director. Most recently he was stationed for two years at the Army Chemical Center in Maryland as a group leader of piloting processes for the manufacture of toxic agents.

▸ **Robert C. Houser** has been elected treasurer of H. K. Porter Company, Inc. Houser succeeds **James C. Leslie,** who has resigned to become president of Holgate Company, Kane, Pennsylvania. **Rocco J. DiFonso** has been named assistant treasurer and **Edward R. Moran** assistant secretary. Houser joined Porter a little more than a year ago as assistant treasurer after having been manager of the Pittsburgh, Pennsylvania, office of Peat, Marwick, Mitchell & Company. Moran was formerly a partner in the Toledo, Ohio, law firm of Cobourn, Yager, Notnagel, Smith & Moran. DiFonso was with the Bureau of Internal Revenue before being employed in Porter's accounting department in 1951.

R. W. Zahniser

H. C. Clark

▸ **Ralph W. Zahniser** has been appointed sales promotion and advertising manager for Gar Wood Industries, Inc. Zahniser has been with Gar Wood since 1951 and has served in several capacities in sales promotion and advertising. **Harold C. Clark** has been named sales manager, Findlay division. Clark has served in several sales management capacities at Gar Wood since he joined the firm in 1952, including that of Eastern district manager for the Findlay division from 1952 to 1954.

▸ **Clint M. Roberts,** veteran credit manager for Halliburton Oil Well Cementing Company, has been named assistant treasurer and general credit manager. Roberts, who began his career as a cementing truck driver in 1928 at Seminole, Oklahoma, moved to Halliburton's Duncan, Oklahoma, headquarters in 1932, and has headed credit operations since.

C. M. Roberts

T. W. Painter

▸ **Thomas W. Painter,** vice president for administration of Welex Jet Services, Inc., has been elected to the board of directors of the company. Painter, who joined Welex in 1950 has been in charge of the company's administrative and manufacturing divisions, and prior to joining Welex, he was comptroller of the Texasteel Manufacturing Company.

▸ **Peter B. Davies** has been appointed to the new position of assistant sales manager of Philadelphia Gear Works. Davies has been a sales engineer with the company since 1948.

▸ **John G. Richards** has been appointed a petroleum engineer in the oil loan division of The Fort Worth National Bank. Richards was formerly a reserves and valuation engineer with the Texas Company, before joining the staff of the bank.

▸ **W. A. Fox** has been transferred to Oklahoma City as division manager of Oklahoma, Kansas, and North Texas for Tuboscope Company. He is a veteran of

W. A. Fox

V. Goins

ten years with Tuboscope and has seen service in Louisiana, Mississippi, New Mexico and Texas. **Vernon Goins** is the new division manager in New Iberia, Louisiana. He went to work for Tuboscope in Oklahoma City in 1944 and was division manager in Oklahoma City for eight years before his transfer to New Iberia. **C. A. Yancey** is now district manager in Shreveport, Louisiana, a new district created in January, 1955. Yancey joined Tuboscope in 1951 in Odessa, Texas, as a sonoscope operator and has since worked in sales in Abilene and New Iberia.

A new sales office has been opened in Denver, with **Charles Kromer** as representative. Kromer joined Tuboscope in 1951 and had been a sales representative in Corpus Christi, Texas, since last January. Also opened was a new sales office in Dallas, Texas, under the direction of **William Penn McIntyre Jr.** He went to work at Tuboscope in 1950, working on a sonoscope crew in New Iberia and has been a representative in Houston, Texas since 1954.

▸ **Theodore A. Haller** has been named vice president and director of engineering of American Tractor Corporation. He has been chief development engineer at the Allis-Chalmers Springfield, Illinois, crawler tractor plant.

▸ **Robert S. Chamberlin** has moved to Chicago Bridge & Iron Company's San Francisco, California, sales office, transfering from the general sales office in Chicago, Illinois. Chamberlin joined the company's plant in Salt Lake City, Utah, in 1949. **Arthur G. Albertson** has been assigned to the Los Angeles, California, sales office. He joined the firm in 1952. **Julius D. Holmquist** has been transferred to the company's Philadelphia sales office.

▸ **Richard W. Hoyt** has been appointed assistant to the president of the C. Lee Cook Company. Prior to joining Cook, Hoyt was vice president and chief engineer of the Double Seal Piston Ring Company. He was graduated from Purdue University with a degree in mechanical engineering. **Joseph C. Lepic** has been made sales engineer in the Wisconsin-Michigan-Chicago, Illinois, area territory. Lepic was formerly with the Armour Research Foundation.

R. W. Hoyt

▸ **Lawrence F. Williams** has been elected president of The Cooper-Bessemer Corporation. Williams succeeds **Cordon Lefebvre,** who had previously requested

J. E. Brown

L. F. Williams

the board consider his resignation because of health. Lefebvre had been head of the company for 14 years. **James E. Brown,** treasurer, was chosen to serve also as secretary, replacing Williams. Formerly a director and secretary of Cooper-Bessemer, Williams has held numerous positions in the management of both the company's plants in Mount Vernon, Ohio, and Grove City, Pennsylvania.

Brown was elected treasurer in 1947 and subsequently named to the positions of director and vice president of Cooper-Bessemer International and director and treasurer of Cooper-Bessemer of Canada, Ltd.

▸ **Benjamin J. D. Bruff** of Knoxville, Tennessee, assistant to the director of explosives sales for Atlas Powder Company since 1954, has retired under the company's pension plan after more than 43 years service. He has been with the company since its establishment in 1912, and for more than 17 years was manager of the Knoxville office.

▸ **William M. Smith** has been promoted from sales representative, New York City-North Jersey area, to the sales division at the home office of Selas Corporation of America. **William C. Schneider** has left the Rochester, New York, territory to replace Smith. **Kenneth E. Rasmussen,** associated with the company's sales engineering department, has replaced Schneider. **Harry E. Morton** has become a sales representative in the Chicago, Illinois, district. Morton joined Selas recently, coming from Hagan Corporation, with whom he has been associated as Chicago district manager.

▸ **George A. Lindquist** has been made construction manager of the H. K. Ferguson Company's 10-state western district, with headquarters in San Francisco, California. A 30-year Ferguson veteran, Lindquist has served as project manager on some of the company's largest construction jobs. **Edward J. Connelly** has been promoted to the post of chief purchasing agent for the San Francisco district office. Connelly has served as assistant chief buyer in the company's central district office in Cleveland, Ohio, for the last 10 years.

▸ **Fred H. Hayes** has retired as vice president and district manager of Clark Bros. Company, Houston, Texas. He had served as head of the Houston office since it opened in 1935. Succeeding him as manager of the Houston district office will be **Ernest G. Hotze,** assistant manager there since 1952. Hotze is a director and member of the executive committee of the Southern Gas Association.

▸ **S. A. Guerrieri** has been appointed to the technical staff of The Lummus Company. Guerrieri, who at one time was a member of The Lummus Company's process engineering department, most recently was chief process engineer of Arthur G. McKee and Company.

▸ **Jack G. Walker** has been appointed special sales representative for Milwhite Mud Sales Company, with headquarters in Houston, Texas. Walker will be in charge of export and industrial sales, a new department.

▸ **Vincent V. Tivy,** formerly manager of refinery instrument sales for The Foxboro Company, has been made the firm's chief application engineer. He will also serve on Foxboro's engineering executive and sales product committees.

▸ **A. M. Kohler,** vice president of The Babcock & Wilcox Company and head of its refractories division, has retired from the company, and active charge of the division has become the responsibility of **J. E. Brinckerhoff** as manager. Kohler joined the B&W Company in 1913 at its former Bayonne, New Jersey, plant. Brinckerhoff joined B&W in 1919 and was appointed manager of the refractories division in 1953.

▸ **Walter V. Stearns** has been appointed to the newly created position of chief petroleum engineer of The H. K. Ferguson Company. He has been active in the process design field for more than 25 years, and has been associated, either directly or through engineering firms, with a number of major oil companies in the United States, Mexico and Japan.

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SAN FRANCISCO

Charles E. Webb, assistant to the general manager of the Sharples Chemicals division of the Pennsylvania Salt Manufacturing Company, has been named manager of services at the division's Wyandotte, Michigan, plant. Replacing Webb will be **Albert Malmsten,** cost engineer at the Wyandotte plant and formerly assistant to the plant manager.

William M. Oliver has been appointed process development engineer at the Port Huron, Michigan, plant of Acheson Colloids Company. He replaces **Bart Dickey,** who has been promoted to production manager. From 1951 to 1955, Oliver was engaged in plant and equipment design for E. I. DuPont Company, including one year on design work for the Savannah River project for AEC.

M. B. Garber and **E. C. Brekelbaum** have been elected vice presidents of The Thew Shovel Company. **C. B. Smythe,** president, also was elected treasurer of the company to replace the late **H. L. Reynolds** and will carry the title of president-treasurer.

Garber has been with Thew for 28 years in various top positions, most recently director of sales. Brekelbaum came to Thew in 1952 as director of methods after 17 years association with the Harnischfeger Corporation, where his last post was vice president and executive chief engineer.

George V. Holton, formerly chairman of the board of Socony Mobil Oil Company, Inc., has been elected a director of The Perkin-Elmer Corporation.

He was board chairman of Socony Mobil until his retirement in July of last year.

Robert M. Van Tassel has been appointed head industrial designer for Joy Manufacturing Company, attached to the Pittsburgh, Pennsylvania, executive staff Van Tassel has been with Joy for seven years and prior to that was engaged in product development and design for the Cadillac division of General Motors.

Donald E. Stoops has been appointed manager of distributor sales for Clark Equipment Company's transmission division although he will continue to supervise the advertising and merchandising program. Stoops was formerly advertising and merchandising manager for the division.

Robert U. Haslanger is now director of industrial sales for Stauffer Chemical Company. Haslanger, who will continue to make his headquarters in New York City, had been eastern sales manager. The appointment fills the vacancy created by the death, some months ago, of **T. A. Haschke. P. S. Brallier** has been named technical advisor to the president. Brallier, who can count almost 40 years of service with the company, had been director of market research and development. The company has also appointed **A. N. Wohlwend** director of market research and development. He moves up from the post of sales development manager.

Robert P. Young has been named manager of the New York City district office of Peerless Pump division, Food Machinery and Chemical Corporation, succeeding **F. W. McCann,** resigned. Young has been a Peerless sales engineer, with headquarters in Pittsburgh, Pennsylvania.

C. L. Peterson has been appointed vice president and general manager of the Brown Instruments division, Minneapolis-Honeywell Regulator Company. A 28-year man with the firm, Peterson had formerly been divisional vice president.

Warren Carhart has been appointed sales manager of Texas Alloy Products Company. Just prior to this new affiliation, he had been general manager of Southwestern Gear division of Western Gear Company in Houston, Texas.

R. C. "Bob" Thompson has been named as Fluid Packed Pump Company's export representative, with headquarters in Maracaibo, Venezuela. He will work with the company's distributor, The National Supply Company, to service Oilmaster products throughout Latin America.

Gordon P. Larson, former smog control director of Los Angeles County, California, has been appointed vice president of Oxy-Catalyst, Inc. Larson, who for six years was director of the Los Angeles Air Pollution Control District, joins the company to assist in the development and application of the company's catalytic fume and odor control and industrial waste heat-recovery systems. While Los Angeles smog director, he conducted the multi-million dollar research program that led to the discovery of the main cause of smog—the unburned hydrocarbon fumes that enter the air primarily as a result of auto engine and plant combustion.

Larson last year served as president of the Air Pollution Control Association. He is author of numerous scientific papers on air pollution and its control.

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Stitt "X" Type Sour Gas plugs resist corrosive action of sour gas — last months longer — require fewer changes — cut "down" time. It's not the plug price, but the "change cost" that's important! Stitts cost a little more — save hundreds of dollars per engine per year. Factory equipment in Clark, Cooper-Bessemer, Worthington, other leading engines.

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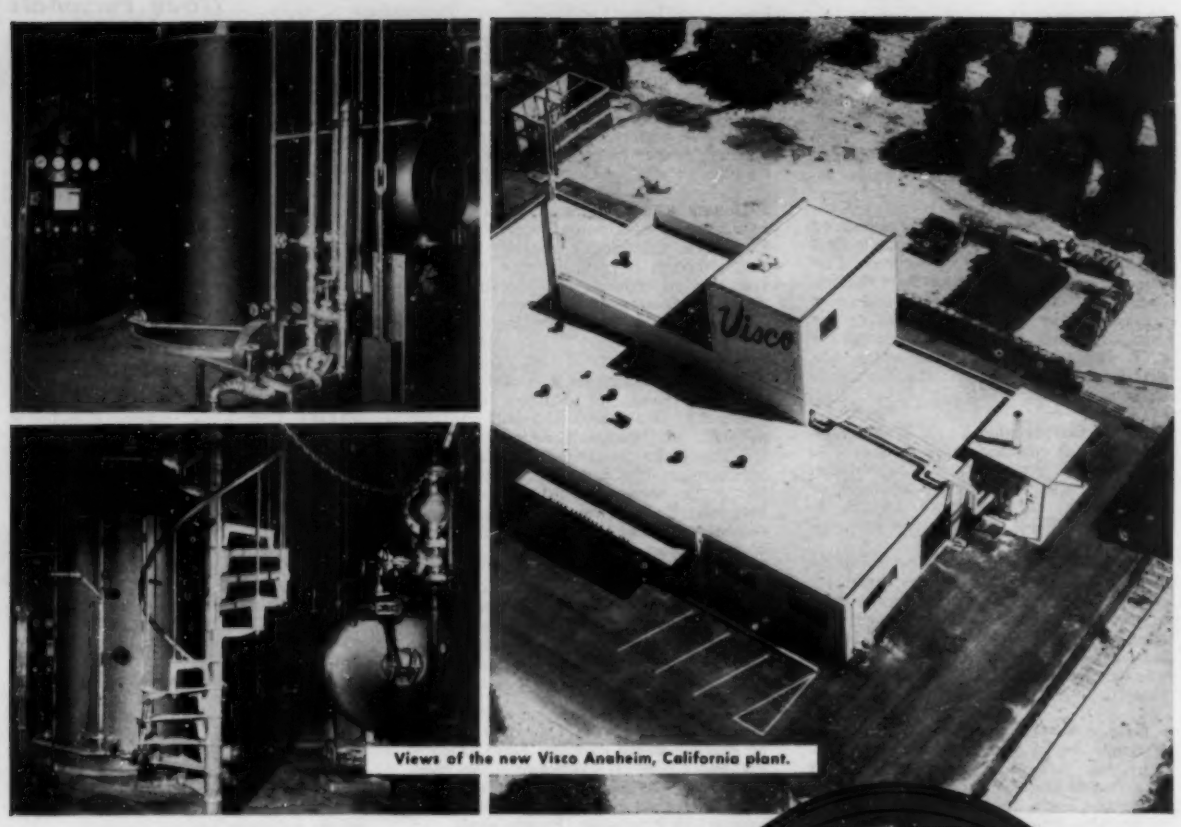

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The ***Petroleum*** **Engineer**

P. O. Box 1589

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NEW oil and gas Equipment

- machinery
- supplies
- services

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

Combination Pressure and Vacuum-Relief Valve. Fluid Mechanics has designed a valve for low-pressure tanks needing both pressure and vacuum relief. On the vacuum side, the valve can be set to open on as little as one inch of water differential, and can be set to exhaust at ½ psi to 150 psi. On the pressure side, the valve can be modified to relieve in overpressure or to relieve in blowdown control.

Fluid Mechanics Company of Houston.

Circle number (1) on reply card.

Iron-Powder Maintenance Electrode. Lincoln Electric has introduced the first iron-powder type electrode especially for maintenance and repair welding. The new electrode, Jet-Hard BU-90, is for fast build-up of worn parts at low cost. It produces a medium-carbon, medium-alloy deposit for building up worn parts with a dense, moderately hard, tough machinable surface to resist shock and abrasion.

The Lincoln Electric Company.

Circle number (2) on reply card.

Compact Low-Cost Gas Scrubber. The purifier, called Hi-eF Type L, has been developed by V. D. Anderson Company for the recovery of liquid present in natural gas. Unit separates liquid and mist entrainment from butane, methane and other gases in two stages, the first by impingement in a baffle section and the second stage by controlled centrifugal action. Small in size, units are available in sizes 2½ in. through 10 in. and with design pressures up to 300 psi.

The V. D. Anderson Company.

Circle number (3) on reply card.

Indirect Heaters. Delta Tank Manufacturing Company's oil field equipment division has announced production of a new line of 10 to 24-ft long indirect heaters with rated heating capacities from 250,000 to 4,000,000 Btu per hour. Units are designed to perform a number of oil field jobs, among them the prevention of hydrate formation in both gas and gas-condensate streams of transmission or production systems.

Delta Tank Manufacturing Company, Inc., subsidiary of General Gas Corporation.

Circle number (4) on reply card.

Oakite Hurriclean Gun. The Hurriclean Gun has been introduced by Oakite Products. Main feature of the gun is the sealed rotary joint that makes it possible to rotate the nozzle without twisting or wrestling with heavy solution or steam hoses. While the forward end of the gun revolves to clean at any desired angle, the handle and hose connections remain stationary.

Oakite Products, Inc.

Circle number (5) on reply card.

V-belts Strengthened with Celanese Fortisan-36 Rayon. A basic problem in the V-belt construction created by the extreme stresses encountered in many specialized V-belt-type transmissions is now being answered by use of cords of Celanese Corporation's Fortisan-36 rayon. Thermoid Company engineers report that the new cords contribute to superior performance even under higher loads and higher temperatures and enable a service life considerably longer than that of these conventional cords. Yarn used by Thermoid in the new cords at the present time is an 800/3/5 construction and (an 800 denier yarn twisted 3-ply in one direction and 5-ply in the opposite direction) but may go to a 1600 construction in the future.

Celanese Corporation of America.

Circle number (6) on reply card.

Compressed-Air Powered Floodlight. A new type of explosion-proof floodlight, powered by compressed-air turbo generators and cooled by exhaust air has been introduced by Copco Eastern. The new 150-w, 12-v TGB 41 floodlight is especially adapted to refinery and industrial work where electric power is not readily available and emergency applications. An automatic turbine cut-off ensures full safety in the event the blast-proof lens is shattered by external impact during operation. Another feature of the floodlight is a filtering device which prevents foreign matter from entering the turbo-generator.

Copco Eastern, Ltd.

Circle number (7) on reply card.

IN DRILLING, PRODUCING . . .

Compact Accumulator Unit. This unit has been developed to power blowout preventor closing units at a remote location. These "Power Packaged" Accumulators furnish 3000 psi working pressure and are available in 30 to 100-gal sizes. The individual accumulator bottles (10 gal each) manifolded together allow the system to operate even if one of the nitrogen-filled bags within the bottles should fail.

Stewart & Stevenson Distributing Company.

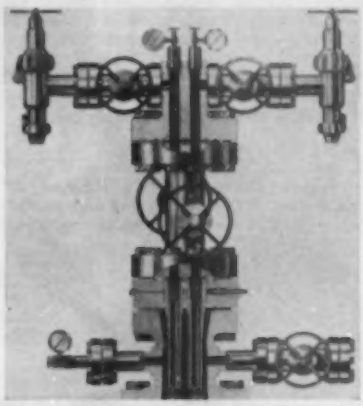
Circle number (8) on reply card.

Corrosion Inhibitor. Dearborn Chemical has announced a new corrosion inhibitor for use in the oil field. Dearborn ENDCOR 50 is a specific chemical treatment for the control of corrosion in both sweet and sour oil wells. It is a strongly polar-type, organic corrosion inhibitor incorporated in a non-oil-soluble, water dispersible, liquid carrier. Treatment is is preferentially absorbed as an impervious film on the metal surfaces of pumps, tubing, rods, and flow lines, thus protecting them from corrosive elements in the oil or brine.

Dearborn Chemical Company.

Circle number (9) on reply card.

Dual-String Hanger Flange. Rector Well Equipment Company has developed a Dual-String Hanger Flange, utilizing the metal-to-metal seal on tubing strings for dual completions. The Dual-String Hanger



Flange has two separate full-opening bores, in which the threaded mandrels seat and suspend the tubing. The mandrels are furnished with an "O" ring to effect a temporary seal during completion work and the flange is also grooved for a hold-down locking screw. When the mandrel is landed in the flange, a metal seal ring seated in the groove at the junction of mandrel and flange provides a metal-to-metal seal when the valve is flanged.

The Dual-Hanger Flanges are available in 6 and 8-in. sizes in any series. A special off-set adapter spool permits use of regular preventer equipment with alignment over each individual bore while running and pulling tubing. Metal-to-metal seals allow the entire Christmas Tree assembly to utilize Rector dual ring gaskets between flanged connections.

Rector Well Equipment Company, Inc.

Circle number (10) on reply card.

Seismograph Replaces Three Seismic Systems. Southwestern Industrial Electronics has announced the new G-33 Full-Spectrum Seismograph System. The G-33 Seismograph covers the seismic spectrum over the entire range of frequencies from 4 to 600 cycles per second and can be used for refraction, conventional reflection, and high-frequency recording with no additional equipment required.

Southwestern Industrial Electronics Company.

Circle number (11) on reply card.

Tool for Repairing Damaged Pipe. Combination packing hanger and casing bowl is used as a casing patch tool and requires no cementing to form a seal or overlap of casing to the surface. No rotating is required to set tool, just set down and pull up to effect a seal. Repair operations can be made to casing at a point below the casing bowl setting.

Burns Tool Company.

Circle number (12) on reply card.

Sucker-Rod Sand Trap. A new sucker-rod sand trap, known as the Petromec "Sand Sentinel," has been announced by Petroleum Mechanical Development. The "Sand Sentinel" consists of a heat-treated alloy steel sucker rod connector with a Hycar (synthetic rubber) sand trap molded on. It prevents "sanding up" of oil well pumps when pumping stops. When the pump is shut down, the lip of the "Sand Sentinel" fills the bore of the tubing and catches the sand as it settles out, before it reaches the pump to cause excessive wear and sticking.

Petroleum Mechanical Development Company.

Circle number (13) on reply card.

IN REFINING . . .

Speeds Tanker Loading — Latest development in marine loading and unloading of petroleum and chemical products is

a hydraulically controlled marine loading arm introduced by Chiksan. Eight-inch diameter aluminum pipe is joined by swivel joints and can be placed aboard a tanker in less than one minute. It is powered by a 7.5-gpm, 500-psi, vane-type pump and a 3-hp electric motor. A selector valve enables the operator to handle multiple units from one structure.

Chiksan Company.

Circle number (14) on reply card.

Insulation. A heat insulation product that withstands temperatures of 1800 F has been developed by Owens-Illinois Glass. Officials say that the new hydrous calcium silicate product, Kaylo-20, has the advantages of expanding slightly up to 1100 F. Completely immersed in a test furnace at 1800 F, shrinkage is limited to about 1½ per cent.

Owens-Illinois Glass Company.

Circle number (15) on reply card.

High-Pressure Transmitter. A linear, force-balance instrument for pneumatically transmitting measurements of large pressure differences over standard distances has been announced by Hagan. Capable of measuring full-scale pressure differences up to 300 psi, the Hagan Delta "P" Transmitter fills the gap existing when the pressure differences exceed the capacity of standard instruments.

Hagan Corporation.

Circle number (16) on reply card.

Portable Electronic Liquid Leveler. Applicable to all open-type liquid containers and operating in any electrically conductive liquid, Blue M's new Portable Electronic Liquid Leveler is designed to automatically maintain liquid level of bath mediums within a level constancy of plus/minus 0.046 in. This completely portable packaged unit includes electronic relay, high and low-level stainless steel 18-8 probes, solenoid valves, etc.

Blue M Electric Company.

Circle number (17) on reply card.

Refinery Air-Pollution Surveys. API announces the availability of Supplement No. 2 to Volume II on Waste Gases and Particulate Matter of the API Manual on Disposal of Refinery Wastes. The new supplement deals with Air-Pollution Surveys. The supplement is available without charge to all holders of the Fourth Edition of Volume II.

American Petroleum Institute.

Circle number (18) on reply card.

IN PIPELINING . . .

Diaphragm Valve. The Grinnell-Saunders Straightway Diaphragm Valve offers the extra advantages of straight-through flow for handling viscous materials, fibrous slurries, sludges, semi-fluids and solids in suspension. Features are: Ability to handle viscous material without restriction or stoppage, minimum pressure drop and rodding or brushing without removing valve bonnet or possible damage to body linings.

Grinnell Company, Inc.

Circle number (19) on reply card.

Hot-Tap Valve. The Hanby Hot-Tap Valve is specifically designed for use in tapping gas transmission lines under pressure and, after extensive field tests, is now in commercial production. Body of the valve is machined from a solid one-piece forging. There are no bonnets to leak, no bonnet bolts to corrode. Designed in accordance with ASA Series 600 Standard (B16.5), it is also used as a blowdown valve on drips or low places in the line.

Oil Well Supply Division of United States Steel Corporation.

Circle number (20) on reply card.

Quick-Opening Quadra-Type Threader. Beaver Pipe Tools has developed a new Quick-Opening Quadra-Type Threader for use with any power drive. Called the Beaver "78," the new threader threads 1-in. 1¼-in., 1½-in. and 2 in. with only one set of full-width high speed dies, which is the same length as a perfect standard thread in the 1-in. to 2-in. range.

Beaver Pipe Tools, Inc.

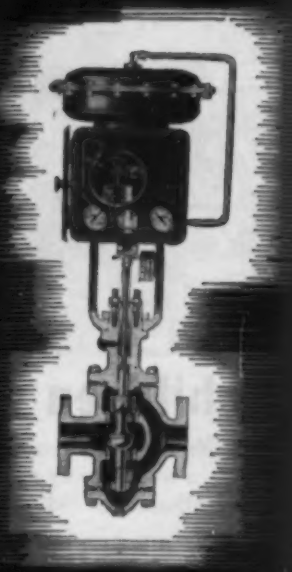
Circle number (21) on reply card.

Off-Highway Trucks. New super-duty B-80 trucks have been introduced by Mack Trucks. Designed especially for the strenuous demands of logging, building, oil field and off-highway jobs, units include both four-wheeled and six-wheeled types with choice of gasoline or diesel power plants and a variety of multi-speed transmissions. *Mack Trucks, Inc.*

Circle number (22) on reply card.

Winch Develops Line Pull of 76,000 Lb. Availability of the world's largest towing winch of matched design for the huge new Caterpillar D9 crawler tractor has been announced by Hyster. The new Hyster winch, model D9A, develops a line pull of 76,000 lb. Unit features a constant-mesh transmission, and flexible-cable handling controls.

Circle number (23) on reply card.



FISHER WIZARD - - - UNIVERSALLY ACCEPTED AS THE WORK HORSE ON PRESSURE CONTROL JOBS

FISHER GOVERNOR COMPANY · Marshalltown, Iowa

WORLD LEADER IN RESEARCH FOR BETTER PRESSURE AND LIQUID LEVEL CONTROL

Your children visit a new world each week

Each Thursday, teacher turns a knob and the class enters a new world—a world many are visiting for the first time via the Standard School Broadcast.

Since 1928, this program has introduced man's musical heritage to Western children. Now playing for its second generation, the Standard School Broadcast is probably the biggest "classroom" in history. It has an audience of nearly 1,500,000 listeners throughout the West, Alaska and Hawaii . . . students in 54,000 classrooms and adult listeners at home. They hear a symphony orchestra, a dramatic cast, choral groups and guest artists. Standard provides Teacher's Manuals as program listening guides.

Goal of the School Broadcast is to help listeners gain an absorbing new interest in music, and—through music—a broader knowledge and understanding of the world around them. We suggest that you listen in at home to enjoy the world's best music and to gain one more link with your childrens' interests. TUNE IN every Thursday . . . check your newspapers for time and station.

STANDARD OIL COMPANY OF CALIFORNIA

plans ahead to serve you better

NEW oil and gas Literature

- brochures
- bulletins
- catalogs

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

Inspection as a Production Tool. This booklet discusses various uses for testing and indicates how a nondestructive testing program can be instituted in the production departments as a cost-reducing, money-saving tool. It outlines how inspection should be considered productive machinery.

Magnaflux Corporation.

Circle number (24) on reply card.

Ductile Cast Iron. A 28-page booklet, ductile iron, the cast iron that can be bent (Revised Edition), with tables, charts and photos has been published by International Nickel. Up-to-date information on ductile cast iron is given, along with photos showing applications of ductile iron castings produced and used in the United States.

The International Nickel Company, Inc.

Circle number (25) on reply card.

Automatic Controls or Measuring Instruments. An index to L&N publications about automatic controls or measuring instruments, or various manufacturing processes in industry has been released.

Leeds & Northrup Company.

Circle number (26) on reply card.

Applied pH Control. W. A. Taylor has released the 25th Anniversary edition (12th) of its handbook, "Modern pH and Chlorine Control," incorporating the theory and practice of colorimetric analysis. The pocket-size, 100-page booklet serves as a handy reference for quantitative determinations of pH, chlorine, bromine, phosphate, nitrate, sulfite, hardness and other special tests. Slide comparators and complete test kits are illustrated and detailed methods are discussed.

The W. A. Taylor Company.

Circle number (27) on reply card.

Hydraulic Tables. A new edition of Bulletin No. 50, "Handbook of Hydraulic Tables and Other Engineering Data," has been made available by Aldrich Pump. This comprehensive, 28-page reference work is for hydraulic engineers interested in pumping and piping problems.

The Aldrich Pump Company.

Circle number (28) on reply card.

Paper Stock and Industrial Liquids Pump. A completely new and patented centrifugal pump, said to be the first real departure from the conventional type of centrifugal pump, has been announced by Ingersoll-Rand in a six-page, two-color bulletin. Classed as a paper stock and industrial liquids pump, it features a diverging-type impeller that enables the pump to handle liquids containing high concentrations of solids, air and gases. This unique design further prevents vapor binding, avoids clogging, makes the pump self-venting and self-regulating.

Ingersoll-Rand Company.

Circle number (29) on reply card.

Aluminum Pipe and Fittings. Aluminum pipe for conveying everything from air to acid is described in an 18-page booklet published by Alcoa. Entitled "Aluminum Pipe and Fittings," the booklet presents the product's characteristics and advantages for each of its major fields of application. Specifications are provided, along with a description of appropriate fittings and methods of installation.

Aluminum Company of America.

Circle number (30) on reply card.

Operational Equations. Berkeley division of Beckman Instruments polishes up the operational equation to short cut electronic computer programming by speedily deriving problem setups. Developed by Hugo M. Martinez, the quick new Berkeley method was unveiled at the LSU High-Speed Computing Conference last February. Data File 120 describes how this direct use of the operational nature of computing elements saves time replacing complex computing circuits with symbolic equations.

Berkeley division of Beckman Instruments, Inc.

Circle number (31) on reply card.

Turbocharging. What is a Turbodiesel? How does a turbocharger work and how is it applied to Cummins diesels? Answers to these and many other questions on turbocharging can be found in a 16-page, four-color booklet released by Cummins Engine Company.

Cummins Engine Company, Inc.

Circle number (32) on reply card.

Materials for Handling Equipment. First of a new series of "fact folders" designed to help manufacturers select the right materials handling equipment for their specific operations has been published by Towmotor. The four-page folders are designed for easy readability and to provide "facts at your fingertips" on any specific series of Towmotor fork lift trucks and tractors.

Additional refcrence folders cover Towmotor's complete constant-power line by models.

Towmotor Corporation.

Circle number (33) on reuly card.

IN REFINING . . .

Steam-Pyrolysis Process. A steam-pyrolysis process that allows the refiner to dispose of marginal products by economically converting natural gasoline, residuals or other low-value materials to ethylene and olefins is the subject of an 8-page booklet published by M. W. Kellogg.

The booklet covers typical yields from the steam cracking of ethane and propane, includes a flow chart and process description of the steam pyrolysis design, and features an overall economic summary of an operating plant.

The M. W. Kellogg Company.

Circle number (34) on reply card.

Swaged Magnesia-Insulated Wires. Aero Research Instrument has issued an illustrated bulletin on its Swaged Magnesia Insulation. These swaged magnesia-insulated wires may be used in temperatures of 2000 F and higher, are easy to use and of long life.

Aero Research Instrument Company.

Circle number (35) on reply card.

Hydraulic (Straight-Thread) Tube Fittings. Parker Appliance has issued a 20-page catalog that provides full dimensional information on new straight-thread fittings with o-ring sealing, both Triple-lok flare and Ferulok flareless types. Included are machining dimensions and drawings for the internal straight-thread boss and listings of the counter-boring and thread-tapping tools.

Parker Appliance Co.

Circle number (36) on reply card.

Scientific Tools. The new, illustrated Fisher catalog supplement describes in about 100 pages, all of the instruments, apparatus, glassware, laboratory furniture and accessories added to Fisher stocks since 1952 publication of the major Fisher catalog. A special Canadian edition of the supplement will be published simultaneously.

Fisher Scientific Company.

Circle number (37) on reply card.

Analysis of Gases and Liquids by Gas Chromatography. A 12-page, illustrated Burrell booklet describes The Kromo-Tog, a new self-contained instrument for the analysis of gases and liquids by gas chromatography. Fully explained is the elution method of analysis for which The Kromo-Tog provides all of the basic instrumentation needed by the modern labatory. Extreme flexibility is featured for The Kromo-Tog, as it embodies simplicity of design, ease of operation and wide usefulness, including many applications for which there is no other practicable method.

Burrell Corporation.

Circle number (38) on reply card.

Molybdenum Disulfide Lubricants. Bulletin 103A, a four-page, two-color catalogue of the variety of Molykote Lubricants now available to industry has been published by Alpha Molykote. Bulletin lists 17 types of molybdenum disulfide lubricant. Highlight of the bulletin is a selector chart that describes each Molykote type, the temperature range and the proper method of application.

The Alpha Molykote Corporation.

Circle number (39) on reply card.

Electro-Hydraulic Actuator. Catalog 22 describes a new actuator design to fill a need for a precise positional control — at high response speeds — for valves, slides, gates and other mechanisms.

Weighing & Control Components, Inc.

Circle number (40) on reply card.

Trade Literature

Packaged Steam-Supply Units. Eclipse Fuel Engineering has issued Bulletin A-771, which presents the complete line of Dowtherm vaporizers and "Steam-boilerplants."

Fully described and illustrated are the automatic, packaged Dowtherm vaporizers (horizontal and vertical) for high-temperature, low-pressure vapor or liquid-phase systems for a wide variety of process heating applications.

Also described in the bulletin are the Eclipse "Steamboilerplants" for industrial and commercial steam users.

Eclipse Fuel Engineering Company.

Circle number (41) on reply card.

Refractory Castables. J. H. France Refractories has issued a four-page service and promotional bulletin on its complete refractory castable line. The color bulletin contains a special section devoted to the company's standard refractory line. Technical data tables for each product show modulus of rupture, linear change, cold crushing strengths and installation requirements.

J. H. France Refractories Company.

Circle number (42) on reply card.

Analytical and Control Instruments. Consolidated Engineering has released two bulletins, one on the Process Refractometer for monitoring and control of petroleum and chemical processes and the other a general catalog of analytical and control instruments. Included in the catalog is an explanation of the Mass Spectrometer Principle.

Consolidated Engineering Corporation.

Circle number (43) on reply card.

IN DRILLING, PRODUCING . . .

Tubing and Surface Safety Valves. Otis Pressure Control has issued an eight-page bulletin on the entire line of tubing and surface safety valves that it markets to oil and gas operators. The folder describes the purposes, operating principles and design details of the valves, and illustrates typical installations.

Otis Pressure Control, Inc.

Circle number (44) on reply card.

PVC Pipe Fittings and Flanges. Unplasticized Polyvinyl Chloride (PVC) pipe fittings and flanges are the subject of a new booklet issued by Tube Turns Plastics. It discusses industrial applications of PVC piping and gives complete specifications for threaded and socket types of PVC fittings, and PVC flanges, in both normal and high-impact grades.

Tube Turns Plastics, Inc.

Circle number (45) on reply card.

Spliced Slings. Several new developments in Tuffy Slings have necessitated a new and expanded edition of Union Wire Rope's Sling Handbook. Foremost of new developments, according to Union Wire Rope engineers, is a streamlined, heavy-walled, steel ferrule eye splice. The 1955 Tuffy Sling Handbook contains 60 pages of illustrations, charts and diagrams describing 16 different factory-fitted slings and nearly two dozen standard fittings available for slings.

Union Wire Rope Corporation.

Circle number (46) on reply card.

Plastic Pumps. Catalogue No. 55 on Vanton Flex-i-liner Plastic Pumps has been announced. Illustrations and diagrams of both standard and XB Models, complete operating and performance data, along with materials of construction and recommended application tables, are included. Full details are given concerning the "no stuffing box, no shaft seal, no check valve" design of this pump, which operates by means of a rotor mounted on an eccentric shaft.

Vanton Pump and Equipment Corporation.

Circle number (47) on reply card.

Crawler Tractor. The technical and operating story of the HD-16 crawler tractor is now available from Allis-Chalmers' tractor group, construction machinery division. This new two-color brochure includes a pictorial review of the design, engineering, and operating advancements that combine to make the HD-16 outstanding in its weight and horse power classification.

Allis-Chalmers Manufacturing Company.

Circle number (48) on reply card.

Gravity Conservation. Black, Sivalls & Bryson announces publication of a fully illustrated 24-page bulletin on Gravity Conservation that summarizes several gravity conservation methods now being practiced in the oil fields and introduces some new thinking recently developed. Divided into four main sections, the bulletin discusses the importance of conservation in terms of dollar return, reviews equipment now being used on the storage tank to increase vapor conservation and discusses new aids in gravity conservation.

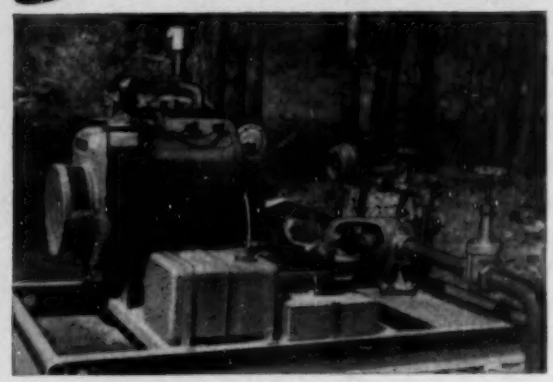
Black, Sivall & Bryson, Inc.

Circle number (49) on reply card.

WISCONSIN Powered

OIL FIELD UNIT

Pumps 30 bbls. per hr. at 600 lbs. pressure



Pumping heavy viscous oil, this unit delivers about 30 bbls. per hour at 600 lbs. pressure. Dependable Lugging Power is supplied by an open type Wisconsin Model VF4D V-type 4-cylinder engine. It is operating in southern Oklahoma.

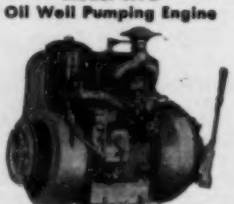
This Wisconsin engine is equipped with clutch reduction and operates on natural gas. Being of the "open" type, easier repairs and adjustments are greatly facilitated.

Weatherproof under the most severe conditions, this engine is ideally adapted to rugged, self-sufficient service in out-of-the-way locations and is rapidly becoming one of the most popular models in oil field service.

Heavy-duty construction features include tapered roller bearings at both ends of the crankshaft, high tension rotary type outside magneto with impulse coupling for easy starting at low cranking speed in any weather, Stellite-faced exhaust valves, positive type valve rotators and solid Stellite valve seat inserts for long engine life and minimum maintenance—plus extremely efficient AIR-COOLING even at high atmospheric temperatures.

You can't do better than to specify "Wisconsin Power" for your oil field units. Wisconsin Engines are available in complete power range from 3 to 36 hp.

Model TFPD
Oil Well Pumping Engine



Get the details about this 2-cylinder Wisconsin Oil Well Pumping Engine with built-in High Momentum Factor.

WISCONSIN MOTOR Corporation
MILWAUKEE 46 WISCONSIN
World's Largest Builders of Heavy Duty Air Cooled Engines

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OIL FIELD DISTRIBUTORS FOR WISCONSIN ENGINES AND ALL TYPES OF UTILITY UNITS

Trade Literature

Fluid Injection. The Interstate Oil Compact Commission announces the publication of a pamphlet, "More Oil for America," a panel discussion presented by the chairman and members of the Interstate Oil Compact Commission at Denver, Colorado, June 18, 1955, entitled "Significance of Fluid Injection Operations in the United States." This compilation includes some 16 papers.
Interstate Oil Compact Commission.
Circle number (50) on reply card.

Indirect Heaters. Delta Tank Manufacturing Company's oil field equipment division has announced a 24-page manual on a new line of 10 to 24-ft long indirect heaters whose rated heating capacities range from 250,000 to 4,000,000 Btu per hour.
Heaters were designed to perform a number of oil field jobs, among them the prevention of hydrate formation in both gas and gas-condensate streams of transmission or production systems.
Delta Tank Manufacturing Company, Inc., subsidiary of General Gas Corporation.
Circle number (51) on reply card.

Waterflooding Pumps. Choosing the right waterflooding pump for secondary recovery operations is the subject of a four-page bulletin by Worthington. Bulletin information is also applicable for subsurface hydraulic pumping and salt water disposal operations.
Worthington Corporation.
Circle number (52) on reply card.

IN PIPELINING . . .

Couplings and Compression Fittings. Dresser Manufacturing Division announces a catalog describing how Dresser couplings and compression fittings are used for piping in petroleum marketing. Illustrated, both by photographs and drawings, the catalog explains simplified methods of pipe connecting and maintenance.
Dresser Manufacturing Division of Dresser Industries, Inc.
Circle number (53) on reply card.

Repair Clamps and Service Fittings. A catalog on repair clamps and service fittings for steel and cast iron pipe has been published by M. B. Skinner. The 48-page booklet contains specifications on the equipment and photographs and drawings as illustrations.
M. B. Skinner Company.
Circle number (54) on reply card.

Trenchers and Backfillers. The complete line of Cleveland trenchers and backfillers is described in a four-page bulletin published by Cleveland Trencher. Revisions in some of the specifications of the Model 80W Cleveland Backfiller constitute the principal difference in text matter between this and the previous Full Line Cleveland Bulletin.
Cleveland Trencher Company.
Circle number (55) on reply card.

Cathodic Protection Systems. Harco has announced the publication of a 12-page illustrated brochure entitled "Cathodic Protection Systems for Corrosion Control." The principles utilized by the Harco system to halt already existent-corrosion action or to keep new installations free of significant corrosion damage are described and illustrated with drawings and actual photographs.
The Harco Corporation.
Circle number (56) on reply card.

CO_2 Welding. A 12-page preprint of an article to appear in the Welding Journal, "Carbon-Dioxide Shielded, Consumable-Electrode Arc Welding," by G. R. Rothschild of Air Reduction's Research Laboratories, Murray Hill, New Jersey, is now available. The article deals with the methods of supplying and the flow characteristics of carbon dioxide, the chemical activity of carbon dioxide, properties of weld metal, operating characteristics and specific applications.
Air Reduction Sales Company, a division of Air Reduction Company, Inc.
Circle number (57) on reply card.

Asphalt Mastic Pipe Line Coating. Timkote, a new asphalt mastic pipe line coating process, has been introduced by Southern Production Company and is described in a 15-page, illustrated brochure released by the company. This new process is said to provide in a single application both protection against corrosion and the additional weight required for marine pipe lines.
Southern Production Company, Inc.
Circle number (58) on reply card.

...the efficiency-balanced

RIDGID

Heavy-Duty Pipe Cutter

Powerfully built—guaranteed not to warp or break, always tracks perfectly . . . Famous RIDGID thin-blade or heavy-duty cutter wheels of tool steel roll easily, cleanly through any pipe.* Every cutter factory-tested! Buy them at your Supply House.

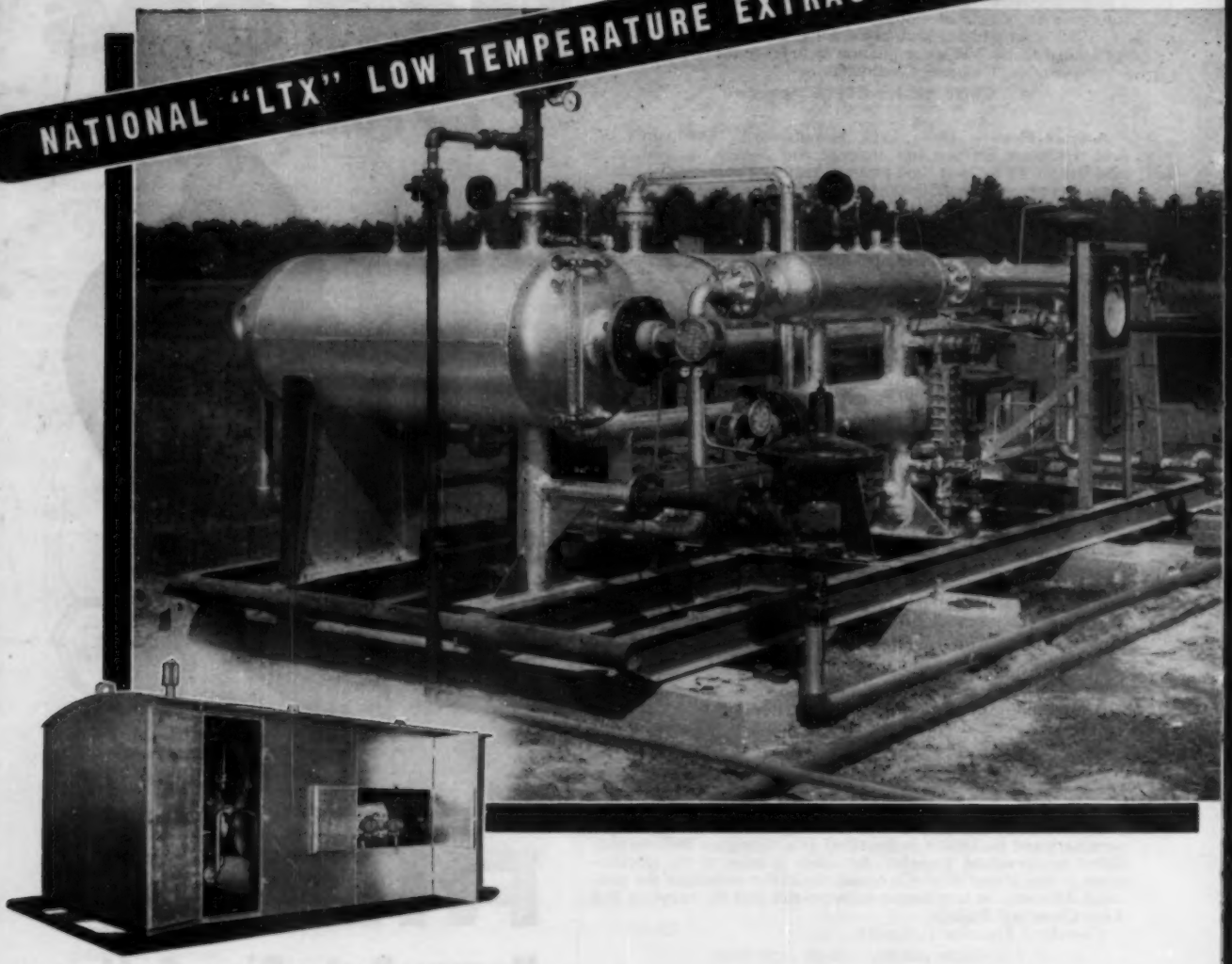
*Special wheels available for stainless steel and cast iron.

For fast easy pipe cutting in tight places, RIDGID 4-wheel cutters.

RIDGID
Work-Saver Pipe Tools

The Ridge Tool Company, Elyria, Ohio, U.S.A.

NATIONAL "LTX" LOW TEMPERATURE EXTRACTION UNITS



Products engineered by National Tank Company are so designed that they become universal for the task they are appointed to do. "Universal" because they are not tailor-made to fit only one set of conditions. They will do the work on many jobs within their rated maximum capacities.

Many "Firsts" have come from "National" — One of the Latest Firsts is the LTX — Low Temperature Extraction Unit.

National LTX Units Produce Maximum Results at Minimum Costs: 1. Maximum Pressure and Flow Stream Recovery of Stable Distillate. 2. Minimum Water Dew Point of Final Gas Stream; Minimum Hydrocarbon Dew Point.

National LTX Units are made in various sizes and capacities.

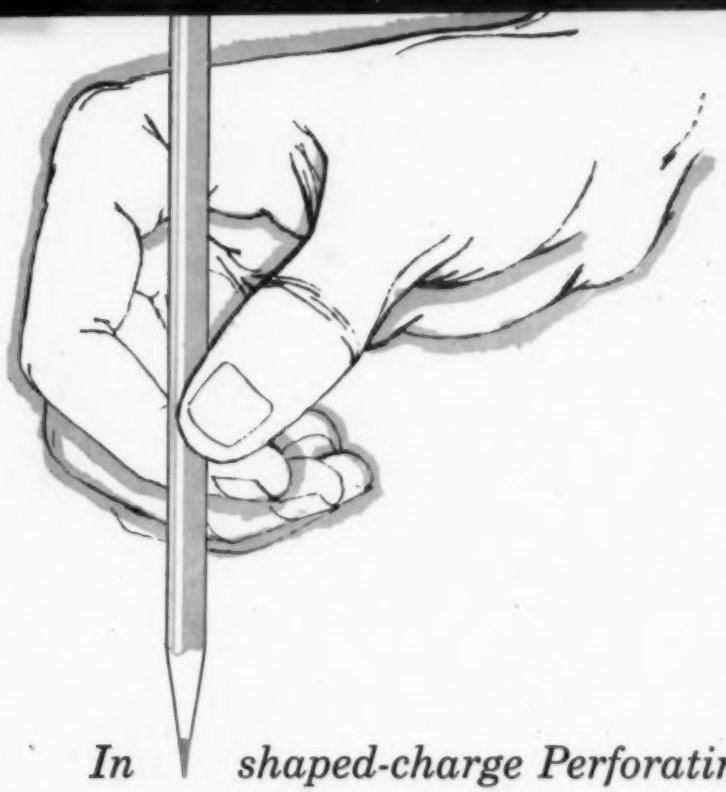
Write for further information.

"LTX" IS A REGISTERED TRADE-MARK

It's a National

NATIONAL TANK COMPANY

TULSA, OKLAHOMA



In shaped-charge Perforating

LANE-WELLS KONESHOT

gives you everything!

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DEEP PENETRATION. **All the penetration of the most powerful shaped charges, insured by such features as Lane-Wells exclusive**

SHOCK-ABSORBING CHARGE ALIGNER **which accurately positions every charge and gives optimum "stand-off" distance for complete, uninterrupted formation of the powerful "force-stream."**

SEMI-SELECTIVE FIRING **with Lane-Wells F-2 Gun, allowing the perforating of two zones on one run, or giving double shot density, if desired, in all or part of a single zone.**

POSITIVE FIRING **of every shot by means of improved detonating devices which insure against misfires.**

ACCURATE SHOT PLACEMENT, **right where you order them, through Lane-Wells famous Depth Measuring System.**

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QUICK, DEPENDABLE SERVICE **by trained men from any of the more than 100 Lane-Wells branches serving every active oil area in this country, Canada and Venezuela.**

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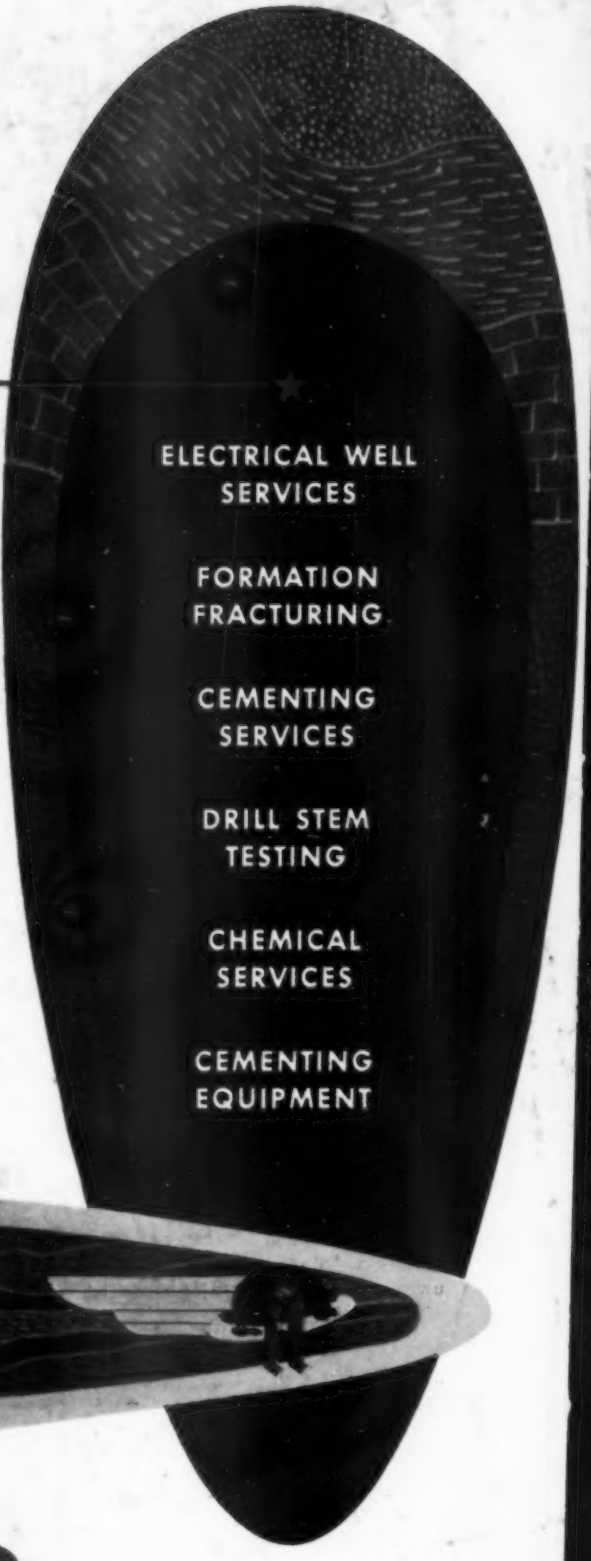
"what's HALLIBURTON doing in all these services?

There's a question with a double meaning. Your tone of voice determines the answer. If you're not using all of Halliburton's services you may be asking *why* we offer so many. The answer is—because *all* these services are important, necessary, and closely integrated. Each helps the other put more oil in the tanks.

If you *are* using all of Halliburton's services, you know about our great research program. You'll be asking what Halliburton is doing that's *new*. And the answer is—we are continually changing the old way of doing things... constantly improving and developing new tools, techniques, and technology ...always making every effort to serve you better, day after day.

However you ask the question, Halliburton answers by performing SERVICE... service beyond the fee, service above all. And, above all, research is our most important service.

PROGRESS IN SERVICE THROUGH RESEARCH



OIL WELL CEMENTING COMPANY

DUNCAN, OKLAHOMA